

Chemical & Process Engineering

Vol. 35, No. 7

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Subscription rates: 1 year 6 dollars, 3 years 15 dollars, paid in advance

England: Leonard Hill Limited, Stratford House, 9 Eden Street, London, N.W.1. EUSton 5911

U.S.A.: British Publications Inc., 30, East 60th St., New York, 22

Topics of the Month

Burma wants chemical engineering know-how

COMMENTING last December on the arrangement between Evans Medical Supplies Ltd. and the Burmese Government whereby Evans are acting as agents in the setting up of a pharmaceutical industry near Rangoon, we pointed out that under-developed countries like Burma are no longer content to buy goods from the Western World but want to make the goods themselves, and the West must be prepared to sell know-how instead. The truth of this observation is borne out by the report of the United Kingdom Industrial Delegation which was sent to Burma by the President of the Board of Trade recently (H.M.S.O., 2s. 6d.). Many chemical and allied projects are included in the Burmese Government's economic development plan discussed in the report, and the number of experienced and qualified Burmese engineers to undertake the design and supervision of these projects is very small. The Burmese Government are fully alive to this and are proposing to employ foreign consulting engineers and architects wherever necessary until their own training programmes bear fruit. It is understood that a sulphuric acid and fertiliser plant and a cement factory are among the projects for which consultants are required at present. In addition, the government are to seek advice from consultants on inspection in exporting countries and on technical queries arising from contracts in hand.

There is no doubt that there are opportunities in Burma for U.K. manufacturers of chemical and processing plant and machinery. In most cases the requirements of the Burmese Government will go out to international tender, but the delegation feel that British industry is in a good position to make fully competitive offers for the types of equipment and machinery likely to be required. But firms must quote firm prices and give quick deliveries.

The new single-rate tariff which came into force in October 1953 improves the position of U.K. goods in competition with those from India and Pakistan, which previously enjoyed preferential treatment. Although the new tariff affords some scope for competition from other European countries, particularly in the case of chemicals, medicines, drugs and textiles, there has so far been no evidence that the competitive position of the U.K. is being impaired.

Another matter with which the Burmese Government is concerned is the serious shortage of qualified engineers. The Engineering Faculty in Rangoon University has about 40 students studying civil, mechanical and electrical engineering and it is planned to increase this number, but this cannot be done until the university secures more lecturers. The report draws the attention of British graduates to Burma's need for lecturers in chemical engineering, mechanical and mining engineering, metallurgy, electrical engineering and architecture.

High-pressure physics

IN many engineering processes the properties of mixtures of different gases are very important. To some extent it is possible to study these properties theoretically, but very accurate experimental work is necessary to establish the theory on a firm basis. At the National Physical Laboratory, Teddington, experiments are now in progress on the properties of certain important gas mixtures up to high pressures and temperatures with the particular object of testing recent theoretical developments. This work is part of a developing programme of work in the field of high-pressure physics. There has hitherto been a lack in this country of fundamental standards of accuracy for the measurement of high pressures, which is usually carried out by instruments known as pressure balances, in which the high pressure in a fluid medium, acting on a piston, is balanced by weights. As part of the above programme the laboratory has undertaken to establish standards of measurement for high pressure, which involves an extensive investigation of the fundamental calibration of pressure balances. Some aspects of this work were shown recently at the Annual Open Day of the N.P.L.

New gas-making plant

THE rising costs of coal, the steady decline in resources of good gas-making coal and the equally steady increase in demand for gas are the three biggest problems facing the British gas industry. Coal is now costing the industry £29 million a year more than it would have cost at the prices ruling before nationalisation on May 1, 1949. The demand for gas, which rose by 8% during the three years to March 31, 1953, is expected to increase still further as a result of new housing and the continually growing use of gas in industry. By 1959-60 total gas consumption is estimated as 2,924 million therms p.a., compared with 2,524 million in 1952-53.

To meet these demands the industry is embarking on a vast seven-year development plan which will cost some £366 million. Details are given in a new booklet *Fuel for the Nation*.

To solve the technical and economic problems arising from the coal situation, the industry is endeavouring to increase the efficiency of its gas-making plants. It is reckoned that the industry would today need over three-quarters of a million tons of coal more annually were it not for the improved efficiency of production achieved since vesting day. But this is only a partial answer. Increased quantities of coke oven gas are now being bought and more use is being made of water-gas plant which uses coke instead of coal. All these measures combined mean that by 1960 it is expected that coal demand will rise by only 6% compared with an increase in gas production of 15%. Other ways of saving coal being tried include the gasification of heavy oils, a subject dealt with in an article in *CHEMICAL AND PROCESS ENGINEERING* last month, the use of petroleum gases such as butane, experiments with methane from coal mines and prospecting for natural gas.

However, in spite of these novel experiments, in the immediate future the gas industry will have to meet increased demands from its own plants and plans are being made to raise output by 261 million therms by 1960. The extra capacity will be provided partly by an increase in carbonisation plant from 7,564,000 to 8,078,000 therms/day and partly by an increase in water-gas and other plant from 3,635,000 therms to 4,727,000.

It will be seen that water-gas and other plant will provide most of the increase; in fact, the capacity of these non-carbonisation plants will be increased by 30%. Most of the additional plant will be carburetted water-gas plant. Although this type of plant is cheaper than that used for carbonisation, there are no by-products other than some oil tar. Coke, of which approximately 10 cwt. are made from each ton of coal carbonised, is, by contrast, consumed. On the other hand, plant for the production of gases other than coal gas can be brought into operation to meet requirements in excess of the base load much more rapidly than that used for carbonisation. In addition to this function, such gases are used to adjust the quality of coke oven gas and for the dilution of methane. Where the needs justify it, carburetted water-gas plant can now be installed in very much larger units than was possible in the past. The most recent installation of the North Thames Board at its Beckton works consists of four units, each with a nominal daily capacity of 4.5 million cu. ft. In these units the steam required for the making of gas is almost entirely supplied from their own waste-heat boilers; and before the steam is used for the process it drives an electric generator, which in turn provides all the power needed in the process with a surplus for use in other parts of the works. For small towns and villages which are beyond the reach of grid systems and where the costs of operating orthodox processes are exceptionally high, the liquefied petroleum gases already mentioned provide an alternative. Butane or propane/air plants have already been installed at Whitland, Carmarthen-shire, at Bungay and Framlingham in East Anglia, and at St. Just in Cornwall, with satisfactory results, and more use is likely to be made of plants of this description. Experience and change in the relative demand for fuels may encourage Gas Boards to substitute oil gasification plant for certain of their projected carburetted water-gas installations.

On the organisational side, economy and efficiency is being sought by an integration and interlinking programme designed to concentrate production in the larger and more efficient units. Already since vesting day 180 small gasworks have been closed down and supplies provided from bigger stations.

Competition in the U.S. chemical industry

THOSE who think of the American chemical industry as a monopoly industry will be surprised to learn that there are more than 9,000 chemical establishments in the United States—most of them small, but including at least 27 with assets of more than \$100 million. The sales of the largest chemical company, du Pont, represent only 8½% of the industry's total. There are 16 major competitors in plastics, 19 in sulphuric acid, 50 in coated fabrics, four in photo products, 15 in explosives, 117 in anti-freezes and 1,200 in paint.

These facts were given by the vice-president of E. I. du Pont de Nemours & Co. in a recent address in New Orleans, in which he laid stress on the virility of the American chemical industry and its economic and social importance. He pointed out that, between 1913 and 1919, investment in chemical manufacturing doubled in the U.S., and the industry has continued to grow at the rate of 10% a year, compared with a 3% average for all industry. Today the U.S. chemical industry is exceeded in the value of sales only by the food, iron-and-steel, petroleum-and-coal, machinery and automobile industries. While prophecy might be dangerous, a five-fold increase was expected by 1975.

Comical Engineering Terms



"FLUID CONTACTING APPARATUS"

Accelerating the application of research

THE problem of bridging the gap between scientific research and its industrial utilisation—a problem intimately connected with higher productivity—was discussed recently by Mr. W. Leonard Hill, chairman of The Leonard Hill Technical Group, London, which publishes *CHEMICAL & PROCESS ENGINEERING* and 12 other monthly technical journals and a number of reference works. Mr. Hill was delivering the chairman's address to the Agriculture Group of the Society of Chemical Industry at Burlington House, London. Calling his address 'Making Known,' he spoke of the role of the private publisher in the process of disseminating technical information.

Mr. Hill began by referring to a recent letter in *Nature* criticising the failure of the Colonial Products Research Council to publish results of publicly financed work on insecticidal sprays which cost £900,000. Undoubtedly much useful technical information was being permanently lost because of the reluctance of the people concerned to write up their work for publication. Some industries were excessively secretive, in contrast to the much freer exchange of technological information in the United States which so impressed various Anglo-American productivity teams.

In contrast to the comparative paucity of technological information in Great Britain, there was no lack of research papers emanating from more academic organisations. The difficulty here was to get all these papers published. It was at this point that Mr. Hill discussed the rapid utilisation of new discoveries and suggested that scientists should send their research papers to the technical Press for speedy publication. If such papers were accompanied by editorial summaries pointing out their significance in less technical language, they would attract the keen interest of technologists and business men and the application of pure knowledge would be accelerated.

The greater part of Mr. Hill's address consisted of a detailed account of the work of the various partners in the business of technical book publishing—the author, publisher,

printer, binder, paper maker and bookseller. Their relationships with each other were described in fascinating detail based on an experience of over 30 years in publishing. The preparation of manuscripts, initial negotiations with the publisher, proofs, copyright (British and American), reviews and the selling of technical books were all discussed by Mr. Hill. The importance of book reviews was underlined by Mr. Hill, who pointed out, to the surprise of many of his audience, that there was a number of books on the technique of reviewing. Another point emphasised was the importance of the technical bookseller who worked for comparatively small returns and whose role in the process of 'making known' was not always properly appreciated.

The long and lively discussion that followed Mr. Hill's address testified to the great interest and appreciation with which it had been received.

Bringing home raw material costs

A NEAT device for impressing on design staff the relative cost of different materials—not always immediately apparent from specification data—is used in the design department of Marconi Instruments Ltd. A wide variety of materials is displayed on a board on which it is stated that each piece is worth one penny. Since each piece has the same cross-sectional area, the lengths give a direct indication of value. Comparison between materials is immediately obvious, as is the intrinsic value of any individual material.

In the interests of simplicity, no attempt has been made to relate strengths or to show the effect on the cost of the finishes necessary on some material to ensure climatic resistance or electrical suitability.

Simple though this device is, its effectiveness is frequently demonstrated by the comments of visitors and new staff, to many of whom the comparative value of some of the common materials apparently comes as a shock.

Advice on effluent disposal

THERE is a mass of legislation prohibiting the pollution of rivers and streams by the discharge of trade effluent, and the requirements of municipal authorities vary from one locality to another, so that the factory owner is frequently perplexed. Generally the local authority requires the removal of solid matter in suspension in excess of 500 p.p.m., pH limits of from 6 to 10 and in some cases from 5 to 12, a temperature below 110°F. and a limit on chrome and cyanide and other toxic ions dependent on the size of the local sewage works in ratio to the quantity of effluent. A charge is also made for the reception and treatment of the effluent. Charges depend on the cost of running the sewage works and the type of effluent the factory discharges. There are a number of other chemicals used in industry which can interfere with the running of the sewage works, and the foregoing figures serve only as a general guide to the conditions likely to be met by a factory owner who is considering the discharge of trade effluent to the public sewers.

The toxicity standards laid down by the local authority can frequently be met either by provision of a balancing tank at the factory, so that the other effluents from the factory dilute the toxic one to the acceptable figure, or by some modification in the process. In the paper industry, many firms have reduced their total effluent by the re-use of backwater. Elaborate precautions have been taken in dairies and milk processing factories to prevent the entry of milk

into the sewers; special precautions with 'drag-out' in the plating industry could reduce the escape of toxic chemicals into the sewer. Many individual factories have reduced and in a few cases eliminated the discharge of their effluent to rivers by treating it and re-using it in the factory in a closed-cycle system. In some cases this makes possible the simultaneous recovery of raw materials for re-processing.

These and many other considerations concerning industry's effluent disposal problems are discussed in an extremely helpful handbook, 'Disposal of Waste Waters from Industrial Premises,' which has been published by the Federation of British Industries (2s. 6d.). The handbook explains in simple language all the main legal requirements and the important technical points which arise therefrom.

New mineral dressing laboratories

A HANDICAP to the development of the large low-grade ore deposits on which modern industry increasingly depends, and which is felt in every part of the world, is the shortage of trained mineral-dressing engineers. In the U.K., the Mineral Dressing Section of the Royal School of Mines expects to meet part of this need during the next few years by giving accelerated training to postgraduate students, but it is felt that the long-term answer requires a steady increase in the number of graduates specially trained in this subject. The degree course instituted by the University of London in 1952 should go some way towards meeting the demand. This is a B.Sc. option (engineering) in metallurgy, and it carries with it the associateship of the Royal School of Mines.

The new laboratories built at South Kensington in connection with this degree course and its associated research activities, which have been described in a recent issue of *Nature*, contain a comprehensive range of dry-crushing, wet-grinding and sampling machines. All the machines are protected by a dust-control system which permits virtually all rock treated to be recovered in the end-products. The crushing section is under negative pressure, so that the main testing laboratories are not contaminated by air-borne mineral dusts. In the research section, which is reached through air locks, all air is spray-washed and filtered before entry, the block being kept under a slight positive pressure to ensure freedom from similar contamination. These precautions have been taken because in the local atmosphere a freshly sheared mineral surface receives sufficient hydrocarbon coating from the air in a minute or less to make its surface reactions quite unreliable. Under the new air control, not only the materials being tested, but also the reagents and apparatus, remain chemically clean for reasonably long periods.

Research is being carried out on the use of supersonic waves to influence sorption rate from the water phase through the zeta-zone to immersed mineral surfaces; pressure leaching as a hydro-metallurgical method of direct extraction of metals in the form of soluble salts; sub-sieve sizing by sedimentation and elutriation; radiotracer equipment to be used with fatty acids in the study of sorption phenomena at mineral surfaces; identification of minute quantities of unknown minerals by a combination of selective separation and microchemistry; thin section radiography for micro-examination of minerals and mill products; a motor-driven stage and counting machine for quantitative assessment of particle types under the microscope; and a comparatively new method of testing the surface condition of small particles.

Measures have been taken to correlate the work done in the new laboratories with its commercial utilisation. In this connection, the traditional policy of making suitable provision for industrial ore-testing at the Royal School of Mines has been retained.

Sweden's versatile chemical industry

THE Swedish chemical industry today employs more than twice as many workers as in 1939, and companies report on an average fourfold increases in the number of chemical engineers and in laboratory and office staffs. The country is self-supporting in a very wide range of chemicals and, in spite of high protective tariffs and quota restrictions, exports have increased five- to sixfold.

These facts, given in a survey published recently by the *Manchester Guardian*, are the more creditable when it is recalled that, at the outbreak of the first world war, Swedish production of chemicals was relatively small and confined to a narrow range of products, notably pine oil, tall oil, turpentine, charcoal products, and chemicals for the pulp and match industry. Possessing few of the raw material resources needed as a basis for a well-balanced chemical industry, Sweden seemed destined to fall behind in the new chemical age. However, ample supplies of hydroelectric power and the industrial experience of the wood pulp, mining and steel firms which undertook the development of the chemical industry, combined to overcome the obstacles. Today, a visitor to Sweden will find alongside the great armament and steel works of Bofors a large complex of chemical plants, producing such diverse products as nitrocellulose for paint, procaine hydrochloride for penicillin, dyestuff intermediates, aspirin and saccharin. Adjoining the vast pulp mills of companies such as Mo och Domsjö, Stora Kopparberg, and Uddeholm are further large chemical plants making alcohols, chlorine, caustic soda, ethylene oxides and glycols.

In the beechwood forests of southern Sweden a flourishing wood-chemistry industry, originally started in 1883 for the production of vinegar from pyroligneous acid obtained by the dry distillation of beechwood, is now making some 60 standard products such as alcohol, wood naphtha, creosote oil, ketones, formaldehyde and plastics. With the experience gained in the manufacture of fatty acids for their candle factory, Liljeholmens Stearinfabriks have entered the field of fatty acid nitrogen derivatives. Another example of a new industry founded on a traditional one is provided by Svenska Oljeslageri A.B. Until the second world war this concern only produced linseed oil and pressed cattle cake; now it makes close on 200 products including synthetic resins, plasticisers, textile finishing agents and detergents.

Stockholms Superfosfat Fabriks A.B. is the country's biggest electrochemical concern and sells carbide and ammonia, as well as nitric acid, ammonium nitrate, ammonium sulphate, ammonium carbide and cyanamide. This firm, with its sister company, Reymersholm Gamla Industri A.B., and others, have made Sweden self-supporting in superphosphates and produce about 30% of domestic nitrogen fertiliser needs.

Sweden's big copper-making concern, Stora Kopparbergs Bergslags A.B.—often described as the oldest company in the world—has based its modern manufacturing activities on the ownership of extensive forests, iron mines and waterfalls for power, and was the first company in the world to build a plant for producing ethyl alcohol from waste sulphite liquor. Today its products include sodium hydroxide, butanol, butyl acetate, iron sulphate, and copper sulphate.

FUEL CELLS

I. Principles, Early Fuel Cells, High Temperature Cells

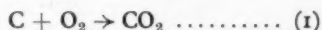
By A. M. Adams, M.A., A.Inst.P.

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In this article the general principles involved in the design of fuel cells or primary cells for the electrochemical oxidation of fuels are examined and a survey is made of various types of such cells that have been proposed. Broadly, fuel cells may be classified into high- and low-temperature groups and in both groups considerable advances have been made since the end of the war as a result of investigations in the United Kingdom, the United States, the Soviet Union and elsewhere. Development is most advanced in the field of low-temperature hydrogen-oxygen cells and small-scale applications of such cells within the next few years are possible in such fields as electric traction. Problems encountered in the design of high-temperature gas cells have not yet been completely overcome, and low-temperature solid-fuel systems incorporating electrochemical oxidation processes are still in the research stage, but if experimental investigations now in progress are successful, further specialised applications, such as to chemical and metallurgical processes requiring low-voltage d.c. supplies, can be envisaged. Generation of bulk supplies of electricity for general use by these means would involve further problems of scale, transmission and distribution; economic solutions to these are not easily visualised.

BEFORE Faraday's invention of the dynamo, batteries of electrochemical cells provided the only practicable means of generating appreciable electric currents. However, most primary cells involve the oxidation of a metal, most frequently zinc; the relatively high cost of metals makes the use of such primary batteries uneconomic for large-scale generation of electricity and this is now almost exclusively carried out by means of electromagnetic machines driven by heat engines or water or wind power. In many regions of the earth's surface such natural sources of energy are not available or cannot be harnessed economically. Also the pioneering work of Carnot in the middle of the 19th century led to the realisation of the thermodynamic limitations of practicable heat engines as converters of energy. Subsequently, the theoretical advantages of generating electricity by the electrochemical oxidation of the fuel became evident. Cells designed for this purpose have become known as fuel cells, and many eminent scientists and inventors, such as Ostwald, Rayleigh and Mond, have made considerable efforts to solve the problems involved. Even before this, several attempts had been made to carry out the electrochemical oxidation of fuels (e.g. Davy, 1802;¹ Grove, 1839²). In spite of continued improvements in the thermal efficiency of generating plant, electrochemical oxidation would be theoretically more efficient and is therefore worth attention today.

The greater proportion of fuels are of a predominantly carbonaceous composition and the ultimate source of electrical energy generated from such fuels is the loss of energy from the system that occurs during the reaction



by whatever route may be selected and whether it occurs in a furnace or in an electrochemical cell. In practice, however, it is only feasible to carry out this reaction directly at high temperatures. This is not disadvantageous when the object is to produce heat for use in some form of heat engine; indeed, by the first law of thermodynamics, the higher the utilisable temperature the higher the efficiency of the heat engine. In a fuel cell, however, operation at temperatures higher than ambient must result in heat losses, which represent a loss of efficiency.

For carbon and oxygen to react electrochemically, one or both of the reactants must form ions. Carbon does not form stable ions at any temperature likely to be attainable in practice and a practicable fuel cell must therefore involve the reaction of oxide ions, or oxygen containing ions, with the fuel substance. Even oxygen ionises only reluctantly at ordinary temperatures, in the presence of suitable catalysts or activated surfaces which enable the energy barriers involved to be surmounted. Hence a cell operating according to equation (1) may be regarded as impracticable, and the only types of cell that have functioned satisfactorily even in the laboratory either operate at high temperatures or involve preliminary reactions between the fuel and other substances outside the cell. Cells of the latter type are sometimes termed indirect fuel cells, but as many high-temperature cells also involve some initial processing of the fuel, at least to the extent of gasification, it is more convenient to classify fuel cells into high- and low-temperature groups. As an arbitrary division, the former group may be con-

sidered to consist of cells operating above 250°C. and the latter of those operating below that temperature.

Before considering any cells in detail, it will be advantageous to examine in some detail the general principles involved in the operation of fuel cells.

Electrochemical principles

The principles involved in fuel cells do not differ from those common to all galvanic cells, the basis of which may be considered to be as follows: two or more substances capable of reacting together, if brought into contact under suitable conditions, are separated by an electrolytic barrier, so that reaction can only occur by migration of ions from one substance to the other through the electrolyte. If electrodes are provided for discharge of the ions at the electrolyte boundaries and are connected through an external circuit, the reaction will continue until chemical equilibrium is established between the reactants and products, but immediately the compensating flow of electrons through the external circuit connecting these electrodes is interrupted, the reaction should cease. The electrolyte may be an aqueous or non-aqueous solution, a fused or solid ionic conductor or, in principle at least, an ionised gas. For reasons already mentioned, it must be capable of transporting oxygen in an ionised form from the air or oxygen electrode to the fuel electrode. The oxygen may be transferred as O^{2-} or OH^- ions or as part of an ion such as CO_3^{2-} or MnO_4^{2-} , but in these latter instances the electrolyte must permit the residue of the ion to diffuse back to the oxygen electrode, where it can reform the CO_3^{2-} or MnO_4^{2-} ions. If this diffusion process cannot occur

or the rate of diffusion limits the overall reaction rate, the cell will suffer from concentration polarisation. Where the CO_3^{2-} ion is concerned, it would be possible to avoid the need for this diffusion process by supplying sufficient carbon dioxide to the oxygen electrode from the waste gases to maintain the required concentration of CO_3^{2-} at this electrode.

In low-temperature cells, aqueous electrolytes may be used; reaction rates may be increased by raising the temperature, if necessary above the boiling point of the electrolyte, by applying pressure. At high temperatures, on the other hand, fused or solid electrolytes must be used; difficulties arise with fused electrolytes, owing to the occurrence of irreversible side reactions between the electrolyte and the fuel or the constructional materials of the cell. 'Solid electrolytes' (Baur and Preis, 1937³) offer some advantages over fused electrolytes, but it is difficult to select a material having a high ionic conductivity together with good ceramic properties. It will be realised that conduction in most solids is by electrons, as in metals and semi-conductors; any appreciable amount of electronic conduction will prevent the cell functioning as intended by short-circuiting the electrodes internally. Ionic conduction in solids and fused salts has not been studied intensively, however, and there would appear to be scope for more research on possible electrolytes for high-temperature cells. The ceramic properties of solid electrolytes are also important; unsatisfactory characteristics result in the electrolytic barrier becoming pervious to oxygen or fuel gases. As an alternative to solid electrolytes, fused salts held in a porous ceramic material have been employed (e.g. Baur, Treadwell and Trümpler, 1921;⁴ Greger, 1934;⁵ 1939;⁶ 1942;⁷ Bischoff, 1951⁸).

Thermodynamic considerations

Under thermodynamically ideal conditions, the work done by the current flowing in the external circuit would be equal to the difference in free energy ($-\Delta G$) between the reactants and the products. In general, even under such ideal conditions, there will be some evolution or absorption of heat ($-T\Delta S$, where T is the absolute temperature and ΔS the change in entropy) during the reaction and therefore the decrease in enthalpy or heat content ($-\Delta H$) during the corresponding combustion reaction will not be equal to the decrease in free energy. The relation between these quantities can be expressed by the well-known equation:

$$-\Delta H = -\Delta G - T\Delta S \dots (2)$$

In this equation the term $-T\Delta S$ represents the minimum change in heat content that can occur in the system and, under non-ideal conditions, which must of course prevail if the reaction is to proceed at an appreciable rate, the amount of energy degraded into heat will exceed this value.

It is the object of fuel cell design to keep the proportion of free energy degraded into heat as low as is compatible with economic operation, in order to obtain the maximum possible amount of useful work from the cell.

For most chemical reactions ($-\Delta G$) is smaller than ($-\Delta H$) and so the amount of useful work obtainable from the system is less than the corresponding heat of reaction. For reaction (1), however, the term ($-T\Delta S$) in equation (2) is small, so that ($-\Delta G$) is practically equal to ($-\Delta H$). Equation (2) may be rewritten in the form usually known as the Gibbs-Helmholtz Equation:⁹

$$-\Delta H = -\Delta G - T \left(\frac{\partial \Delta G}{\partial T} \right)_p \dots (3)$$

where $\left(\frac{\partial \Delta G}{\partial T} \right)_p$ is the rate at which the

free energy change varies with absolute temperature, at constant pressure. It therefore follows that, for this reaction, the free energy change will vary little with temperature and in fact the values are 94 Kcal. at 25°C. and 93 Kcal. at 1,500°C. per gramme atom (12 g.) of carbon. For other reactions, however, the decrease in free energy varies widely at different temperatures.

The e.m.f. of an electrochemical cell is determined by the free energy change

accompanying the cell reaction, since the reaction of each gramme molecule of reactant must be accompanied by the passage of n Faradays of electricity through the cell, where n is the number of electrons concerned in the reaction per molecule of reactant. The work done by the current must equal the decrease in free energy and so:

$$E = \frac{-\Delta G}{nF} \dots (4)$$

In this equation $-\Delta G$ must be expressed in joules and F is the number of coulombs in a Faraday (96,500). In reaction (1), four electrons are concerned in the reaction for each atom of carbon or molecule of oxygen. Substituting the values already quoted, the e.m.f. of a cell operating on this reaction should be 1.02 v. at 25°C. and 1.01 v. at 1,500°C.

Fig. 1 shows the variation of free energy and the corresponding cell e.m.f. for a number of reactions, in the form originally used by Ellingham (1944)¹⁰ and with additional data of Richardson and Jeffes (1949).¹¹ The curves (except as noted in the next paragraph) relate to reactions under standard conditions involving one gramme molecule of oxygen; at the base of the figure, lines are shown which enable the appropriate corrections to be made for non-standard conditions when the partial pressures of gaseous substances differ from

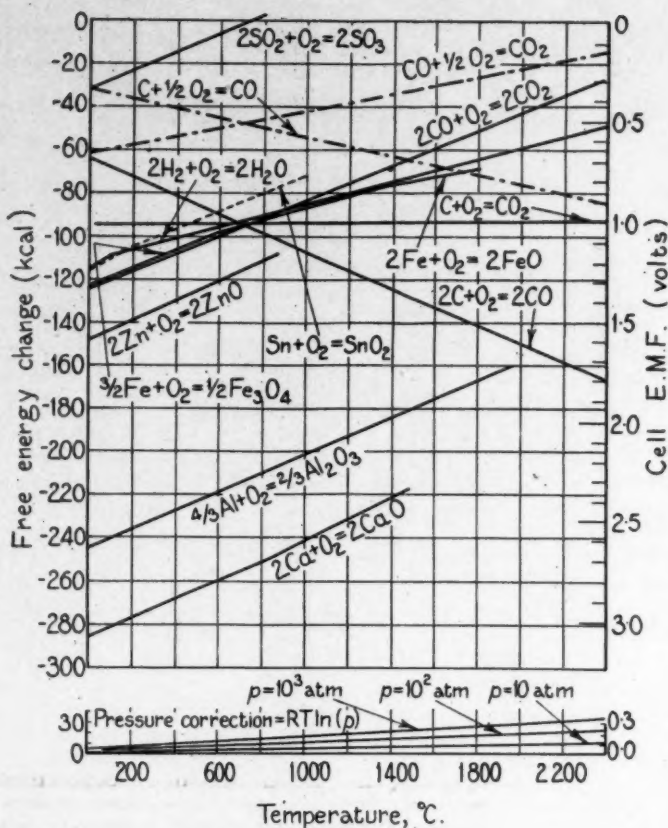


Fig. 1. Variation of free energy and cell e.m.f. with temperature.

one atmosphere, it being assumed that partial pressures may be employed in place of fugacities. These corrections can be calculated, since the free energy change ($-\Delta G$) is related to the standard value ($-\Delta G^\circ$) by the equation:

$$-\Delta G = -\Delta G^\circ + RT \ln K_p \dots\dots (5)$$

K_p being the chemical equilibrium constant for the reaction at constant pressure, R the gas constant and T the absolute temperature.

Two further curves (chain line) are shown in Fig. 1 which shows the variation in free energy for the reactions



per gramme-atom of carbon or gramme-molecule of carbon monoxide. The significance of these curves will be discussed later, but it may be noted that the e.m.f. scale shown as the right-hand ordinate does not apply to these two curves.

From Fig. 1, it will be seen that the voltage to be expected from a single cell will be of the order of 1 v.; reactions such as the oxidation of sulphur dioxide to the trioxide, although put forward for use in fuel cells (Basset, 1906),¹² appear to be unsuitable, since low voltages imply low efficiencies. Since the reactants must either be natural fuels or substances easily prepared by reduction with fuels, reactions such as the oxidation of zinc are also not suitable, because these involve preliminary extraction of the metals, which can only be carried out with carbon at very high temperatures and involve large heat losses. The use of reactions based on the oxidation of tin has been studied (Rideal and Evans, 1921),¹³ as this reaction satisfies the thermo-

dynamic requirements, but in practice it appears that the only reactions that are likely to be of value involve the oxidation of carbon, carbon monoxide or hydrogen. In theory at least, hydrogen can be prepared from carbon and steam with negligible energy losses; in practice, thermal efficiencies of 55% (Gordon, 1946)¹⁴ are attainable, but at present the process would not be economic. The use of mixtures of carbon monoxide and hydrogen (e.g. water gas) has frequently been proposed for fuel cells and is thermodynamically sound.

The fuel cell problem is basically one of chemical kinetics, the object being to carry out the selected reaction in such a manner that the proportion of free energy degraded into heat is as small as possible. At the same time, reaction rates must be sufficiently high to make the process economically feasible. Some of the heat produced by irreversible processes may, of course, be partly utilised by means of a heat engine. In low-temperature cells the energy losses tend to be due to activation and concentration polarisation, while in high-temperature cells thermal losses and side reactions tend to predominate. Some ohmic losses in the electrolyte are inevitable, but these may be kept down by reducing the thickness of the electrolyte layer and increasing its cross-sectional area. As a guide to economic reaction rates, two criteria have been suggested: either that the current density should be 100 amp./sq.ft. (108 ma./sq.cm.) or the power output should be greater than 1 kw./cu.m. (28 watts/cu.ft.).

Early fuel cells

The earlier empirical attempts to devise a satisfactory fuel cell are chiefly of historical interest and have been adequately

reviewed by several authors (Fodor, 1897;¹⁵ Berthier, 1929;¹⁶ Baur and Töbler, 1933;¹⁷ Howard, 1945;¹⁸ McKee and Adams, 1949;¹⁹ Danckwerts, 1952;²⁰ and Génin, 1953²¹). Howard's review is particularly comprehensive.

The hydrogen/oxygen cell constructed by Mond and Langer (1889)²² is still of some interest, although the complexity of construction and other adverse factors prevented further development of this cell. The hydrogen and oxygen electrodes consisted of perforated platinum foil coated with platinum black and the electrolyte was a dilute solution of sulphuric acid held in the pores of an asbestos disc. Current densities up to 6.5 ma./sq.cm. (6 amp./sq.ft.) were attained at a voltage of 0.73 v., compared with a theoretical e.m.f. of 1.23 v. for a hydrogen/oxygen cell at room temperature. Polarisation occurred, but its effects were reduced by periodically interchanging the hydrogen and oxygen supplies. It has been suggested that the high cost of the platinum used for the electrodes rendered this cell uneconomic, but it seems at least as probable that the current density was too low and that, unless elaborate purification of the hydrogen were undertaken, the platinum catalyst would soon be poisoned by impurities.

High-temperature cells

Until comparatively recently, most progress was made on high-temperature cells. The work of Baur and his colleagues at Zurich is of particular importance in connection with later developments. In his earlier work (e.g. Baur, 1910)²³ molten electrolytes were used, but after many years he abandoned these in favour of solid electrolytes (Baur and Preis, 1937),³ which were also employed independently about the same time (Schottky, 1937).²⁴ It had been known for many years that glasses exhibit considerable ionic conduction below their melting points and this phenomena had been employed much earlier for theoretical purposes (Haber, 1905),²⁵ but low conductivities and polarisation effects prevented further applications. The Nernst filament lamp was an early application of solid ionic conductors and the same material was at first used by Baur as electrolyte in his cell; it consists of a mixture of rare earth oxides. In later experiments a mixture of tungstic oxide and ball clay with rare earth oxides obtained by calcining monazite (nominally cerium orthophosphate $CePO_4$, but containing varying amounts of other substances) was found to give better results. In Fig. 2, a simple type of cell operating on these principles is shown: the fuel, in the form of carbon granules, was placed inside a thimble formed from the solid electrolyte, which was immersed in a bed of magnetite granules. The latter acted as the air electrode when the whole cell was heated to about 1,100°C. A cell of this type, with an effective electrolyte cross-sectional area of 20 sq. cm., gave 0.70 v. on open circuit

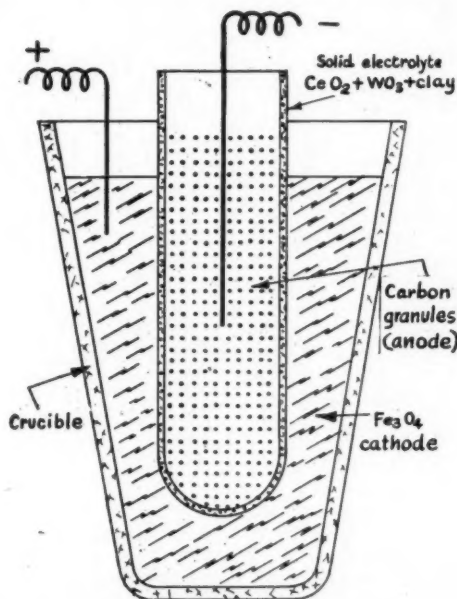


Fig. 2. Baur-Preis cell (1937).

(compared with a theoretical value of 1 v. for a reversible $C \rightarrow CO_2$ cell) and 0.55 v. at a current density of 3.8 ma./sq.cm. (3.5 amp./sq.ft.). As the internal resistance of the cell at this temperature was 2 ohms, the voltage drop on load corresponded purely to resistive losses; no concentration polarisation effects were observed. The electrolyte was 0.1 cm. thick, so that its resistivity under operating conditions was 400 ohm.cm.

Baur and Preis (1938)²⁶ later proposed to avoid some of the difficulties, such as ash accumulation, that would be encountered with a solid fuel by using a gaseous fuel such as producer or water gas. The fuel gas was passed over iron granules which acted as the fuel electrode.

The electrolyte introduced by Baur had a major disadvantage in that the temperature had to be raised above 1,000°C. before the conductivity was sufficiently high for appreciable currents to be taken from the cell and the ceramic properties were not ideal. It was also found, and confirmed by later investigators using x-ray diffraction analysis (McKee and Adams, 1949),¹⁹ that after prolonged operation at 1,100 to 1,200°C. the tungstic oxide was reduced to lower oxides of tungsten and eventually to β -tungsten.

Considerable improvements in high-temperature cells operating on CO, H_2 or mixtures of these gases with solid electrolytes have been reported from the U.S.S.R. (Davtyan, 1947).²⁷ The operating temperature was reduced to an optimum value of 700°C. by adding sodium carbonate and soda glass to Baur's electrolyte. The existence of this optimum temperature was attributed to the effect of the fall in conductivity at lower temperatures on the one hand and the fall in free energy of the $CO \rightarrow CO_2$ and $H_2 \rightarrow H_2O$ reactions at high temperatures on the other, as shown in Fig. 1. The construction of this cell is shown in Fig. 3: the electrodes were clamped on either side of a disc of the electrolyte, air and the fuel gas being circulated over the rear of their respective electrodes, which were enclosed by steel covers. Mixtures of Fe/Fe_2O_3 with 20% clay and Fe_2O_3/Fe_3O_4 with 20% clay were used for the fuel gas and air electrodes, respectively.

On open circuit this cell gave 0.85 v., compared with theoretical reversible e.m.f.'s of about 1 v. at 700°C. for both the reactions involved; at a current density of 32 ma./sq.cm. (30 amp./sq.ft.) the voltage fell to 0.75 v. Again, this voltage drop on load corresponded to the internal resistance of the cell and no polarisation effects were observed. The resistivity of Davtyan's electrolytes was 3 ohm.cm. at 700°C., and even lower values are mentioned. At a current density of 20 ma./sq.cm. (18.6 amp./sq.ft.) the output voltage was 0.785 v. or 80% of the reversible e.m.f.

No further work on this cell has been reported from the U.S.S.R. since 1947, as far as is known. Davtyan mentions that

the electrolyte occasionally cracked during operation of his cells and no prolonged tests were reported in which the stability of the electrolyte and electrode materials might have been established; it is also doubtful whether the current densities mentioned are high enough for economic operation. Further development may also have been delayed owing to economic considerations affecting the production of the fuel gas.

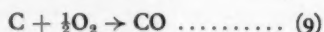
More recently improved methods of operating high-temperature gas cells of the Davtyan type have been reported from the United States (Gorin and the Pittsburgh Consolidation Coal Co., 1951,²⁸ 1952a,²⁹ 1952b³⁰) and fuel cells using porous fireclay impregnated with molten sodium carbonate have been investigated at the University of Technology, Brunswick (Bischoff, 1951).⁸ In both of these studies the experimental results so far published are insufficient to judge the merits of the cells. Gorin gives no indication of how the disadvantages of the Davtyan cell are to be overcome, but it seems likely that, if this is possible, the method of operation described by him would increase the overall efficiency of utilisation of the fuel. As this is of great importance, factors affecting it are worth further examination.

Fuel utilisation in high-temperature cells

It has already been stated that the maximum amount of useful work that can be obtained by the electrochemical oxidation of carbon is equal to the free energy decrease of the $C \rightarrow CO_2$ reaction and is about 93 Kcal. per gramme-atom (12 g.) of carbon, assuming a temperature of 700 to 900°C. and standard conditions. If the partial pressure of the oxygen (p_{O_2}) or of the carbon dioxide (p_{CO_2}) is not 1 atm., the free energy change will be modified according to equation (5):

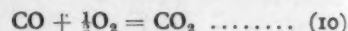
$$-\Delta G_{C \rightarrow CO_2} = -\Delta G^\circ_{C \rightarrow CO_2} + RT \ln \frac{p_{O_2}}{p_{CO_2}} \quad \dots \dots \dots (8)$$

Consider now a high-temperature cell in which the oxygen ions transferred through the electrolyte are in chemical equilibrium with solid carbon and the reaction products; at high temperature, the equilibrium product will be almost entirely carbon monoxide:



The variation with temperature of the standard free energy per gramme-atom of carbon for this reaction is shown near the top of Fig. 1 (chain line), from which it appears that at 900°C. the value will be only 52 Kcal., or about 56% of that for the $C \rightarrow CO_2$ reaction. At low temperatures, this percentage is still lower, but the proportion of CO_2 in the equilibrium product rises and so more than compensates for this decrease. At 700°C., about 40% of CO_2 will be formed.

The complementary reaction to (9) above is:



for which the decrease in free energy will depend on the partial pressure of the reactants according to the equation:

$$-\Delta G_{CO \rightarrow CO_2} = -\Delta G^\circ_{CO \rightarrow CO_2} + RT \ln \frac{p_{O_2} \cdot p_{CO}}{p_{CO_2}} \quad \dots \dots \dots (11)$$

At 900° ($-\Delta G^\circ_{CO \rightarrow CO_2}$) has the value of 41 Kcal.

According to equation (11) the amount of work available from this reaction can be increased by keeping the concentration of CO and O_2 high and removing the CO_2 as fast as it is formed, but if the ratio of CO_2 to CO falls too low, decomposition of the CO can occur:



and carbon will be deposited in the cell, which is undesirable and inefficient.

The e.m.f. available from either of the reactions (9) and (10) between 700 and 900°C. would not differ greatly from that of a $C \rightarrow CO_2$ cell. This follows because, although the free energy values are only about half that for the latter reaction, only two electrons are concerned in the former reactions for each atom of carbon or molecule of carbon monoxide; hence n in equation (4) is 2 instead of 4. In order to obtain the maximum voltages, however, it would be preferable to operate the $C \rightarrow CO$ cell at as high a temperature as possible and *vice versa* for the $CO \rightarrow CO_2$ cell.

From the foregoing, it is obvious that, if a gas cell is operated on producer gas made in a separate plant, only a fraction of the free energy decrease in the $C \rightarrow CO_2$ reaction will be recoverable in the fuel cell; some of the heat produced might be used in a heat engine, but most of it would be wasted. It might be possible to avoid this wastage by employing the $C \rightarrow CO$ and $CO \rightarrow CO_2$ reactions successively in separate cells, but there would be considerable practical difficulties in introducing the fuel and removing ash residues when operating a high-temperature cell on solid fuel. On the other hand, if gasification of the fuel could be carried out by a non-electrochemical reaction without a large wastage of free energy, the design and operation of the fuel cell system would be greatly simplified. It is possible that this could be accomplished by the reverse of reaction (12), the CO_2 being supplied from the waste gases of the fuel cell. The standard free energy change for this reaction is almost zero at 700° and, although for kinetic reasons it might be necessary to operate at a higher temperature, the wastage of free energy could probably be made low.

An alternative solution that has often been suggested would be to operate a fuel cell on water gas. This is theoretically an equimolecular mixture of CO and H_2 ; when oxidised under reversible conditions

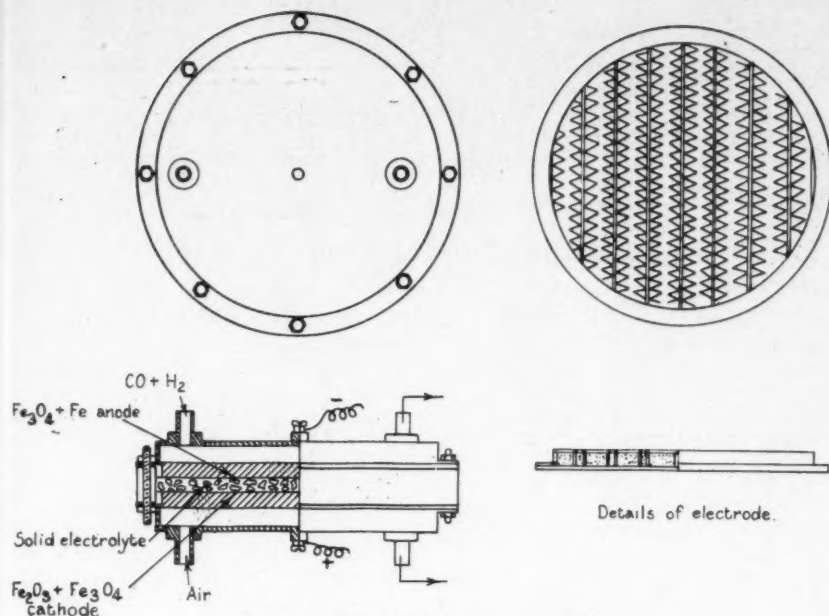
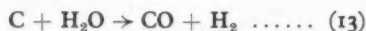


Fig. 3. Davtyan high-temperature cell.

at temperatures near 700°C., the decrease in free energy is very close to that for $C \rightarrow CO_2$ reaction, assuming that the same weight of carbon is used to manufacture the water gas as would be used in the latter reaction. The water gas would be produced by passing steam instead of air over coke:



This reaction, like the reverse of reaction (12), has a negligible free energy change at about 700°C., but it is usually carried out at 900 to 1,000°C. to secure rapid reaction; heat is then supplied to maintain the reaction by periodically substituting an air blast in place of the steam. This practice reduces the efficiency of the process and would preferably be avoided if possible.

According to Gorin's first patent (1951),²⁸ it was proposed to supply the heat needed for the water gas reaction from the waste heat produced by irreversible processes in a battery of fuel cells, by enclosing the battery inside a fluidised-bed gas generator. This scheme has the disadvantage that, if the water-gas reaction is to be carried out at 900°C., the fuel cell would have to operate at a still higher temperature. To avoid this, in a second patent (1952a),²⁹ the fuel cells are removed from the gas generator itself and are used only to preheat the gases supplied to the generator; the temperature of the latter is raised above that of the cells by adding air to the steam supply, so that part of the fuel is oxidised by the exothermic producer-gas reaction. This reduces the overall efficiency of the process and, in his third patent (1952b),³⁰ Gorin reverts to the system of enclosing his cells in the gas generator. The gasification process is now carried out in stages at a lower temperature than normal, so that only part of the steam

reacts with the fuel, the excess steam serving to maintain a high rate of reaction. The resultant mixture of water gas and steam is fed to the fuel cells; the carbon dioxide and some steam produced by the electrochemical process are separated out, while the carbon monoxide, hydrogen and excess steam are recirculated through the gas generator. The practical realisation of all these schemes is dependent, however, on the successful development of a satisfactory high-temperature cell; whether the problems arising in such a development can be overcome has not yet been established. The investigations in the United States are presumably continuing and work is in progress on high-temperature cells in at least two English laboratories.

In the second part of his article, to be published next month, Mr. Adams will deal with low-temperature cells and give a picture of probable developments in the future.

REFERENCES

- ¹H. Davy, *Nicholson's J. Nat. Phil.*, 1802, p. 144.
- ²W. R. Grove, *Phil. Mag.* (3), 1839, 14, 139.
- ³E. Baur and H. Preis, *Z. Elektrochem.*, 1937, 43, 727-732.
- ⁴E. Baur, W. D. Treadwell and Trümpler, *Ibid.*, 27, 199.
- ⁵H. Greger, U.S. Pat. 1,963,550 (1934).
- ⁶*Idem*, U.S. Pat. 2,175,523 (1939).
- ⁷*Idem*, U.S. Pat. 2,276,188 (1942).
- ⁸K. Bischoff, Thesis, University of Technology, Brunswick, 1951.
- ⁹J. R. Partington, 'An Advanced Treatise on Physical Chemistry,' 1, 182 (London; Longmans, Green, 1949).
- ¹⁰H. J. T. Ellingham, *J. Soc. Chem. Ind.*, 1944, 63, 125.
- ¹¹Richardson and Jeffes, *J. Iron Steel Inst.*, 1949, 170, 397-420.
- ¹²L. P. Basset, *Brit. Pat.* 7,375 (1906) and 16,905 (1906).
- ¹³E. K. Rideal and U. R. Evans, *Trans. Far. Soc.*, 1921, 17, 466-482.
- ¹⁴K. Gordon, *J. Inst. Fuel*, 1946, 20, 42-58.

- ¹⁵E. de Fodor, 'Electricity Direct from Coal,' (in German), 1897, Vienna. Hartleben, *Electrotechnischer Bibliothek*, 46.
- ¹⁶A. Berthier, 'Electrical Energy of Tomorrow,' (in French), Desforges, Girardot & Cie., Paris, 1929.
- ¹⁷E. Baur and J. Töbler, *Z. Elektrochem.*, 1933, 39, 139-180.
- ¹⁸H. C. Howard, 'Chemistry of Coal Utilisation,' Wiley, New York (ed., H. H. Lowry), 1945, 2, 1568-1585.
- ¹⁹J. H. McKee and A. M. Adams, *Fuel*, 1949, 28, 1-6.
- ²⁰P. V. Danckwerts, *Indus. Chem.*, 1952, 28, 99.
- ²¹G. Génin, *Electricité*, 1953, 37, 1-7.
- ²²L. Mond and C. Langer, *Proc. Roy. Soc. Lond.*, 1889, 46, 296-308.
- ²³E. Baur, *Z. Elektrochem.*, 1910, 16, 300-302.
- ²⁴W. Schottky, German Pat. 650,224 (1937).
- ²⁵F. Haber and A. Moser, *Z. Elektrochem.*, 1905, 11, 593-609.
- ²⁶E. Baur and H. Preis, *Z. Elektrochem.*, 1938, 44, 695-698.
- ²⁷O. K. Davtyan, 'Direct Conversion of Chemical Energy of Fuel into Electrical Energy' (in Russian), Academy of Sciences, Moscow, 1947. E.R.A. Translation Ref. Trans./1B884 (1949).
- ²⁸E. Gorin and Pittsburg Consolidation Coal Co., U.S. Pat. 2,570,543 (1951).
- ²⁹*Idem*, U.S. Pat. 2,570,650 (1952a).
- ³⁰*Idem*, U.S. Pat. 2,570,651 (1952b).

New Way of Fitting Control Valve Diaphragms

Worn diaphragms in valve mechanisms which automatically regulate process temperatures, steam pressures, humidity, air pressure and boiler feed-water injections in a textile plant may be replaced with a diaphragm that is cut to fit the valve flange inside the line of bolts, thus eliminating bolt holes. Cutting a smaller diaphragm saves material, and eliminating the bolt holes saves time and labour.

The various types of control valves in operation in a textile plant are operated by the water, steam or air acting upon a flexible diaphragm within the valve mechanism. The diaphragms eventually rupture or otherwise become defective, and this results in erratic operation of the valves.

The normal maintenance procedure is to replace the defective diaphragms with new ones which are cut from sheet material made of rubber and interwoven cord, designed for this purpose. It is not difficult to cut the outside circumference of the diaphragm from the sheet material, but cutting holes for the bolts requires a considerable amount of labour.

The problem may be solved in this way: instead of cutting the material to conform to the outside diameter of the valve flanges and then cutting the numerous holes for the bolts, cut a smaller diaphragm that fits snugly inside the line of bolts.

In practical operation, there are no disadvantages to the smaller diaphragm without bolt holes. The idea can be adapted to many types of regulators and control valves. In addition to the advantages of saving labour, time and materials, making the smaller type of diaphragm does not require special cutters, for the rubberised sheeting can be cut with tin snips or a knife.—*Textile Industries*.

OILS AND FATS PROCESSING

Solvent extraction; refining; hydrogenation; fatty acid fractionation; fat chemicals; soap; margarine; lard

By M. K. Schwitzer, M.I.Chem.E.

Solvent extraction

PERHAPS the most interesting development in the field of vegetable oil production is the speed with which cottonseed processors have adopted solvent extraction. Since the first big continuous solvent extractor was erected in 1946 at Wilson, Arkansas, to treat cottonseed, great strides have been made in this sector. Fincher¹ states that there are now seven types of extractors available for this purpose in the U.S.A. But, whereas soya beans are extracted directly, cottonseeds are in most cases prepressed prior to extraction. One processor using direct extraction has worked out a chemical treatment for inactivating the gossypol. The advantages and economics of the direct and prepressing methods of extraction are still open to discussion and it is too early to predict which will predominate in the cottonseed industry.

Solvent extraction has also been introduced to another new field. The V. D. Anderson Co. (U.S.A.) have completed a continuous plant in India for the extraction of 21 tons of mowrah cake a day.² Mowrah (*Bassia latifolia*) seed cake contains a saponine that creates considerable difficulties during both screw pressing and solvent extraction, and the news that it is now possible to solvent-extract mowrah cake continuously marks a definite milestone in oil extraction history.

Lerman³ describes some of the newer solvent extraction systems introduced in recent years, especially those that are designed for direct extraction of cottonseed and other similar materials, including rice bran. One system, developed by the Southern Regional Research Laboratory, New Orleans, U.S.A., is based on the filtration of a solvent slurry containing the raw material in a ground form. Wurster & Sanger Inc. use a horizontal rotary vacuum filter for this purpose in their new system known as the Filtrex process. One such plant is being built in Chile. Based on similar principles is the Rotofil process of the Blaw-Knox Co. and the filtration-extraction plant offered by the Lukenweld Division of the Luken Steel Co., who are starting up a plant for 150 tons/day of cottonseed.

A novel continuous process is the so-called Vibroil process of the Allis-Chalmers Co. The seeds are ground in solvent while

being extracted in a vibratory ball mill as they flow rapidly through it as a slurry. Solvent is removed from the solids in the slurry in a continuous vacuum filter of the drum type. Of European plants, the De Smet process has gained increasingly in recognition. Its advantage is that it can be used on copra and flaxseed as well as on soya beans.

Apart from new systems having been introduced, various improvements in the design of solvent extractors have been recorded. For instance, Hutchins and Simon⁴ describe an extractor which consists essentially of a number of baskets travelling in a horizontal direction, supported by chains. The material to be extracted is fed into the baskets, which are sprayed with a solvent.

Practically all plants use hexane or similar petroleum solvents. Interest in using non-inflammable solvents continues, however. Arnold *et al.*⁵ report on experiments with trichloroethylene in the extraction of various oil-containing materials. Extraction rate data at two temperatures and pilot-plant runs shows that increased extraction times were required for wheat germs, cottonseed, cottonseed meats and milkweed seeds in this order.

Although hexane and similar petroleum solvents are used almost exclusively for oil extraction purposes, there is a persistent interest in the use of ethyl alcohol as a solvent. The reason is that alcohol is cheaply available in several countries where special petroleum-derived solvents are either too expensive or unobtainable. Westergaard⁶ describes a continuous plant for extracting vegetable oils with hot alcohol. On cooling the extract, oil separates out and, after a purification step and the removal of insolubles, the alcohol is re-used without requiring rectification.

Refining

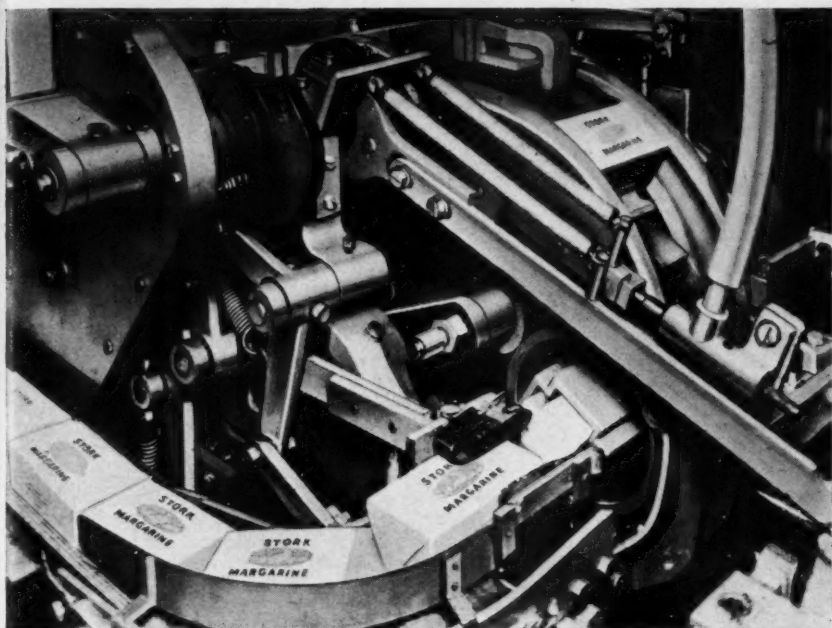
Changes in extraction technique have some influence on the refining methods of the crude oil. The need to produce high-grade oils at the lowest cost also affects designers of refining plant. This trend has made the automatic continuous plant an ideal for designer and processor alike. Summarising recent trends in oil refining, Thurman⁷ states that 'Miscella refining is now being practised on a large scale. The advantage is protection against saponifying

neutral oil in the refining step due to the hexane solvent, which permits the use of a very high excess caustic soda to remove more colour than is obtained by the cup test on straight oil after miscella has been evaporated.' There can be little doubt that refining the oil while still dissolved in the extraction solvent ('miscella') not only gives excellent results economically but also simplifies plant and process for extracting and refining vegetable oils. A miscella refining process was patented by Ziegler.⁸

Though miscella refining is likely to spread, refining of the straight oil is likely to remain standard practice in many factories; especially in those which do not carry out both operations, *i.e.* extraction and refining, on the same spot. An interesting development in oil refining is Clayton's ammonia process. A water solution containing 14% NH_3 is used as the neutralising agent, which can be evaporated subsequently from the ammonia soapstock and re-used as neutralising agent. An unusual soapstock results from this process, which is similar to water-degummed lecithin, but the acetone insoluble (phospholipid) portion is higher.

Progress is reported with some of the established refining methods. The De Laval 'short mix' process for the continuous refining of oils has been described by Braae.⁹ The plant is fully automatic and losses of oil are very small indeed. Describing the plant in some detail, Bierke¹⁰ states that in a first step the oil is freed from mucilage with hot water. The hydrated mucilage is then removed from the oil with a centrifuge, running at about 70°C. The oil is de-aerated and brought into contact with a neutralising solution under pressure. This takes only 2 to 5 sec. The soapstock that is formed in this operation is subsequently removed from the oil with a centrifugal separator of the hermetic type. From the moment the crude oil enters the plant to the moment it emerges in refined form takes only some 40 sec.

Improvements are also reported on the Sharples continuous refining process. Ayres¹¹ describes a proportionometer, with the help of which oil is thoroughly mixed with a 20° Bé alkali solution at the correct rate to neutralise the free fatty acids present in the oil. Operational temperature is between 60 and 75°C. and total contact



[Stork Margarine Works]

Weighing and wrapping of margarine by automatic machine.

time does not exceed 5 sec. This results in a fluid, easily separable soapstock, which is removed with a centrifugal separator immediately after it has formed.

Oil hydrogenation

Oils are refined to be used for edible purposes, though some technical applications also require an oil that has been refined previously. A very large part of the edible refined oils is hydrogenated to give them a higher melting point, greater resistance against deterioration and a whiter appearance. The goal in this sector of the industry is the same as in extracting and refining: namely, a continuous, automatic, foolproof plant. The nature of the problem is such, however, that attempts to hydrogenate continuously have so far not shown the hoped-for success, if at the same time the aim is to make a selectively hardened product. Hughes¹² has critically discussed the whole problem. There are five discontinuous systems of hydrogenation: the intermittent vacuum system; the sustained-pressure systems; the dead-end system; the recirculation system; and the constant-pressure system. Each has its merits, yet none of them can be adapted to work satisfactorily on a continuous basis. He states: 'Some three years ago a series of patents assigned to the Procter & Gamble Co. were issued, covering a continuous hydrogenation process employing a powdered nickel catalyst, but no additional information on the development has been published.'

Similarly, Potts and Morris¹³ have patented a method for continuous hydrogenation which at the same time deodorises the oil. In this system, hydrogenation takes place at a pressure of 20 to 75 p.s.i.

and elevated temperature. Hydrogen is introduced into the convertor in excess of that required for hydrogenation. The hot oil is then passed through a pressure release valve which causes the liberated hydrogen to evaporate, carrying with it odoriferous constituents, thus acting like injected steam in an oil deodoriser. The hardened and deodorised oil is continuously withdrawn from the convertor and cooled.

Margarine

Margarine, compound fats, shortenings and similar solid food fats are consumed on an ever-increasing scale all over the world. Even in the Near and Far East, where dietary habits are so different from Europe and Northern America, oils are hydrogenated and blended with refined liquid oils to make products very similar to our compound fats. India, for instance, has a number of modern factories producing Vanaspati ghee, a product that is used in cooking in a way similar to ghee butter.

The basic problems in the manufacture of all these products come under the heading of 'plasticity.' Plasticity depends on the type of raw materials, on the method of hydrogenation, on the type of chilling units used, on the method of incorporating water or air and on several other factors. Joyner¹⁴ has summarised recently information on this subject, with specific reference to the continuous *Votator*. This is a machine which is gradually replacing the older type of emulsifiers and chilling drums used for decades in the margarine industry. Van den Bergh¹⁵ states that Stork margarine in England is now also produced by the *Votator* process.

With margarine manufacture expanding steadily, mechanical moulding, packing and

cartoning have become a major problem. Foolproof machines to mould more and more packets per minute are a necessity in every modern margarine factory. Küstner Frères & Co. S.A., a Swiss firm, offers a range of machines. One of their machines packs 80 $\frac{1}{2}$ -lb. packets/min., another 55 1-lb. packets/min. A bigger machine is made by the German firm, Benz & Hilgers, which can pack 150 $\frac{1}{2}$ -lb. packets/min. These machines measure the margarine by volume. They are therefore adjustable by means of an instantaneously-acting hand wheel, which will ensure that the packet has a constant weight even if the specific gravity of the margarine changes a little.

Molecular-modified lard

An interesting new product is made from lard. Slater¹⁶ describes a process carried out by Armour & Co. for the production of lard shortening. The product resembles a high-grade vegetable shortening, has a wide plasticity range and can be used with excellent results for baking, deep frying and all other purposes that vegetable shortenings are used for. Essentially, the new process involves a change in the physical structure of the lard as induced under moderate heat by a catalyst. After refining and filtering, the lard is dried under vacuum. It is pumped into the reactor tank where the catalyst (sodium methoxide) is added. The next processing stages serve to remove the catalyst, largely in the form of soaps. The modified lard is then again run through a vacuum drier. The remaining processing steps are the same as for shortenings: deodorising, plasticising, tempering and packaging.

Fractionation of fatty acids

Passing from edible to technical fats, it must be recorded that, though soap-making still consumes the bulk of non-edible fats, other fields are consuming ever-increasing amounts. But, whereas most (though by no means all) of the oils and fats used for soap-making are used in their natural form as glycerides, many of the other technical applications require fatty acids derived from the glycerides by fat splitting. The fatty acids are usually distilled. For some purposes they are further separated and purified.

Up to a few years ago, stearines and oleines, obtained by chilling and pressing split fatty acids, were about the only purified acids available on the market. These products were—and still are—used in candle-making, for rubber compounding, for wool treatment and in other fields. There exists, however, today a demand in the paint, plastics, cosmetics, detergent, chemicals and many other fields for a great variety of special fatty acids. It became necessary, therefore, to separate the crude fatty acids into their pure components, far beyond the degree of separation obtainable by simple pressing.

One way of separating fatty acids is to fractionate them. Malcolm¹⁷ described a

British fatty acid separation plant, while Potts¹⁸ dealt with American practice. German research on this subject was summarised by Stage.¹⁹ The first large-scale fractionation plant was installed in Chicago in 1933. This consisted essentially of one still and one single fractionating tower. This original design developed in stages to the present-day system of three fractionating towers. Crude fatty acids—even those containing moisture—can now be fed directly into the first fractionation column where light ends and moisture are removed. The bottoms are passed into the main column. From the base of this, the highest boiling stock is transferred into the last of three columns for further separation. Fatty acid purities of 96% and more are thus obtainable economically.

Another method of separating fatty acids was suggested by Palmer.²⁰ The fat is again split, but instead of aiming at a high degree of split, the operation is interrupted when about 25% of the glycerides are still present. This material is submitted to a countercurrent liquid-liquid extraction process at a temperature of 232°C. and under pressure. Operating conditions are set in such a way that three products are obtained: an extract phase, containing practically only fatty acids; a raffinate phase, containing the less soluble components of the raw material; and an intermediate phase in which the unsplit glycerides are present.

Principles of liquid-liquid extraction, as applying to the oils and fats industry, were summarised by Pratt.²¹ Plant designs used are discussed and flow diagrams of existing plants are given. Though these plants are at the moment used mainly for oils, they might also be adapted for treating fatty acids.

Fat chemicals

While a large proportion of fatty acids are used without further treatment, ever-increasing amounts are further processed. They are 'stepping stones' in the synthesis of a variety of organic compounds, just like the products of petroleum refining are the basis of the petrochemicals. By analogy the term 'fat-chemical' was recently coined.

A typical example is the production of azelaic and pelargonic acids from 9, 10 di-hydroxystearic acid or by ozonisation of oleic acid. Ricinoleic acid, on the other hand, is a raw material for commercial production of sebacic acid.

Schwitzer²² described the manufacture of special fatty acids and their use in the production of amides, amines and other nitrogenous products, including quaternary ammonium compounds.

Soap-making

The soap industry is waking from a long period of comparatively little development and facing the challenge of synthetic detergents. The fact that often one and the same firm produces both soaps and

synthetic detergents does not obviate the urgent need of the soap-maker to produce better and cheaper products, often requiring new manufacturing methods. While the old-fashioned soap kettle and soap frame still have economic application in many instances, the big soap firms, particularly in the more industrialised countries, are gradually adopting new continuous production methods.

Wells²³ describes the household-soap plant of Lever Brothers (Port Sunlight) Ltd., in which a clever combination of new and old equipment has resulted in a continuous and highly efficient process. The soap pans have been retained, but they only serve as receivers for a countercurrent soap-washing system. Saponification of the oil with caustic alkalis takes place in pipes which feed the saponified mass into the soap pans. The hot, molten soap from the pan room passes over water-cooled drum rolls, on which the soap solidifies into shreds, which are further milled. Air bubbles are removed in vacuum chambers and the automatically-cut bars are then 'weathered' or conditioned. When new weathering towers have been brought into the process, the whole production line from raw material to packed product will be continuous.

A different process, but also producing soap from oils in a continuous manner, is the Monsavon unit. The author had recently the opportunity of inspecting such a unit in operation. It consists of two main sections: saponification and countercurrent washing. The first section comprises a specially adapted colloid mill in which the oil is brought into intimate contact with a caustic alkali solution. Almost instantaneous saponification occurs. The second section consists essentially of a tower subdivided into a number of spaces, each representing one stage in a system of countercurrent washing. In both this and the Port Sunlight system, glycerin recovery is very high—an important consideration.

Lachamp²⁴ discloses details of the Monsavon wash system. A brine is used first, followed by water. The soap/water mixture

is decanted—a nigre is withdrawn continuously. The nigre is re-used in the process.

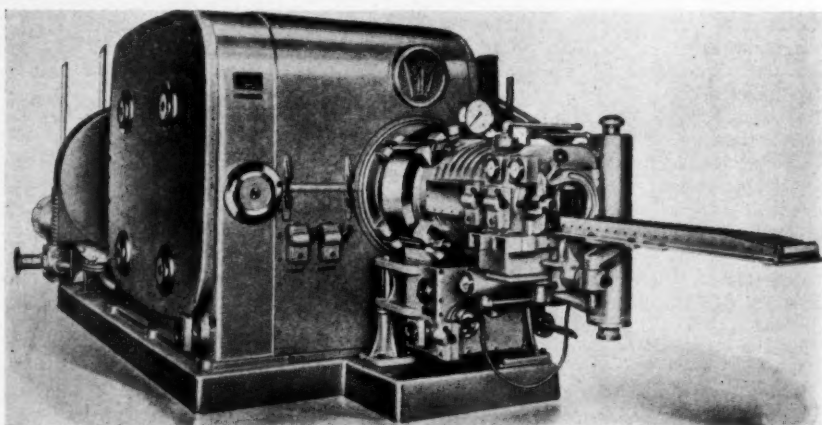
Two new continuous methods for handling soap from kettles or other source were developed in Italy. The Mazzoni process sprays the wet soap into a vacuum chamber fitted with scraper arms. Water evaporates off and is removed. Soap particles collect in the conical bottom of the vacuum chamber, which they leave in the form of spaghetti-shaped rods, which are then worked and extruded in one continuous operation. A modified unit is used for making toilet soap.

The process of Meccaniche Moderne is somewhat similar, but instead of a vacuum chamber, a vessel at atmospheric pressure is used. The wet soap is heated first under light pressure and, as it is released into the chamber at atmospheric pressure, water flashes off as vapour. The amount of water thus removed is controlled by the temperature of the soap feed. The dried soap is then passed through a quadruple chilling unit. Each of these units has a water-cooled cylindrical rotor with scrapers, revolving inside a water-cooled hollow cylinder, reminiscent of the *Votator*. The liquid soap is pressed into the narrow space between rotor and cylinder wall, where quick cooling takes place. From then onwards the soap is treated in more or less traditional manner; both household and toilet soap can be made by this method.

A review of 40 years' progress in soap-making, with specific reference to continuous methods, was presented by Terry.²⁵ A very useful account of new processes, including the continuous Sharples process, was given by Wigner.²⁶

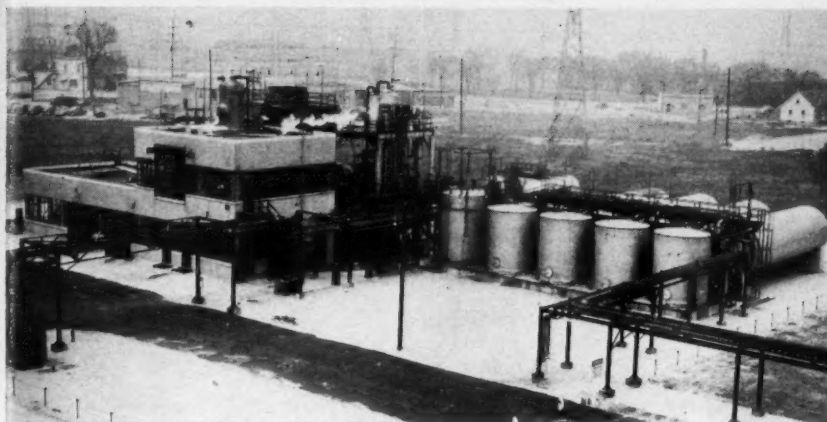
Books

This review would not be complete without mentioning some important books that have appeared on the subject of oils and fats. 'The Lipids,' by Deuel, in two volumes, is a monumental work, dealing with properties of fats, phosphatides, vitamins, etc., and with their biochemistry. Also comprehensive are the volumes pub-



Continuous soap-making plant, showing unit for the extrusion of finished bar soap.

[Meccaniche Moderne, Italy]



[Armour & Co.]

Continuous fatty acids solvent separation plant.

lished under the title, 'Progress in the Chemistry of Fats and other Lipids,' under the editorship of Holman, Lundberg and Malkin. The volumes that have appeared so far have a high standard and are worthy successors of 'Schonfeldt,' known to every oils and fats expert.

The same publishers have given us also 'Drying Oil Technology,' by Mills, and 'Refining of Oils and Fats,' by Andersen, which are most useful monographs on well-defined subjects. Also singling out one specific subject is Vigneron in his 'Fractionnements par solvants,' a discussion of liquid-liquid extraction techniques in the oils and fats industry, while another French author, Catravas, deals with problems of isomerisation during oil hydrogenation. From India come two slim yet useful volumes on 'Studies on the Natural Fats,' by Kartha.

REFERENCES

- ¹H. D. Fincher, *J. Am. Oil Chem. Soc.*, 1953, **30**, 474.
- ²Anon., *Oléagineux*, 1954, **9**, 285.
- ³F. Lerman, *J. Am. Oil Chem. Soc.*, 1954, **31** (4), 27.
- ⁴R. P. Hutchins and F. C. Simon, U.S. Pat. 2,663,624.
- ⁵K. Arnold et al., *J. Am. Oil Chem. Soc.*, 1953, **30**, 393.
- ⁶R. H. Westergaard, U.S. Pat. 2,653,957.
- ⁷B. H. Thurman, *J. Am. Oil Chem. Soc.*, 1953, **30**, 493.
- ⁸J. A. Ziegler, U.S. Pat. 2,670,362.
- ⁹B. Braac, *Fette u. Seifen*, 1953, **55**, 859.
- ¹⁰S. F. N. Bierke, U.S. Pat. 2,657,224.
- ¹¹A. U. Ayres, U.S. Pat. 2,663,719.
- ¹²I. P. Hughes, *J. Am. Oil Chem. Soc.*, 1953, **30**, 506.
- ¹³R. H. Potts and C. E. Morris, U.S. Pat. 2,521,602.
- ¹⁴N. T. Joyner, *J. Am. Oil Chem. Soc.*, 1954, **31**, 526.
- ¹⁵J. P. Van den Bergh, *The Times*, May 11, 1954, p. 12.
- ¹⁶L. E. Slater, *Food Eng.*, 1953, p. 72.
- ¹⁷D. Malcolm, *J. Oil Chem. Col. Assoc.*, 1952, **35**, 502.
- ¹⁸R. H. Potts, *J. Am. Oil Chem. Soc.*, 1953, **30**, 49.
- ¹⁹H. Stage, *Fette Seifen Anstr.*, 1953, **55**, 217, 284 and 375.
- ²⁰G. H. Palmer, U.S. Pat. 2,654,768.
- ²¹T. W. Pratt, *J. Am. Oil Chem. Soc.*, 1953, **30**, 497.
- ²²M. K. Schwitzer, *Soap Perf. Cosm.*, 1953, **26**, 419.

²³F. W. Wells, *Ibid.*, 1954, **27**, 489.

²⁴F. L. Lachampt, U.S. Pat. 2,653,958.

²⁵D. H. Terry, *Soap San. Chem.*, 1954, **30**, 34.

²⁶J. H. Wigner, *Soap Perf. Cosm.*, 1954, **27**, 260.

BOOKS

- A. J. C. Andersen, 'Refining of Oils and Fats,' Pergamon Press Ltd., London, 1953.
- G. N. Catravas, 'Hydrogénation et isomérisation des corps gras par les catalyseurs au nickel sur support,' Institut des Corps Gras, Paris, 1953.
- H. J. Deuel, 'The Lipids,' Interscience Publishers Inc., New York, N.Y., 1951, etc.
- R. T. Holman, W. O. Lundberg and T. Malkin (editors), 'Progress in the Chemistry of Fats and other Lipids,' Pergamon Press Ltd., London, 1952-53, etc.
- A. R. S. Kartha, 'Studies of Natural Fats,' Ernakulam, 1951.
- M. R. Mills, 'Drying Oil Technology,' Pergamon Press Ltd., London, 1952.
- M. Vigneron, 'Fractionnements par solvants,' Vigot Frères, Paris, 1954.

Recent publications

Seventy-five years of engineering.

Thomas W. Ward Ltd. and their subsidiary and associated companies which form the T.W.W. Group of Engineering and Industrial Undertakings have published *Outline of Progress, 1878-1953*, commemorating 75 years of service to industry. This handsome book reviews the activities of all their many concerns, which range from shipbreaking to tarmacadam works, and include factory planning and the installation of plant and machinery. One subsidiary company, Widnes Foundry & Engineering Co. Ltd., fabricates specialised equipment for the chemical industry in mild and stainless steel such as tanks and vessels, stills and retorts. The book comprises over 200 pages printed on art paper and freely illustrated with many full-colour pictures. A limited distribution has been made.

Projection welding of mild steel.

This is the latest addition to the series of technique booklets published by the British Welding Research Association. Prepared by a committee of the Association com-

posed of resistance welding experts from the industry in Britain, this informative booklet covers all aspects of projection welding and is the first available in this country which deals solely with this subject.

Recommendations are made to cover machines and electrodes, materials to be used, types of projections, and machine settings for various thicknesses of material. All are prepared from a series of extensive researches conducted by B.W.R.A. during the past five or six years. The booklet concludes with a section on suggested practices for projection welding based on present industrial experience. It costs 3s. 6d. net.

Automatic controls. Crosby Valve & Engineering Co. Ltd. have issued general catalogue K. 1600 describing briefly the wide range of automatic control equipment manufactured at their works under licence from the Mason-Neilan Regulator Co. of the U.S.A. The catalogue is very comprehensive inasmuch that it gives the available ranges, ratings and sizes of the various types of control equipment, including diaphragm-operated control valves, valve positioners, reducing and back-pressure regulators, pressure controllers, displacement and ball-float type level controllers, etc.

Photoelectric process control. The B.T.L. Absorptiometer Type B, as in the case of the Type A instrument, was designed for the automatic control of a chemical process. It is intended for the continuous measurement of small changes in colour intensity of liquids flowing in a process. Whereas the Type A instrument is self-contained, the Type B can be regarded only as a detector; no amplifier or indicator is incorporated. The instrument is suitable for use with an external self-balancing potentiometer controller. In conjunction with an external controller, the Type B Absorptiometer provides a complete system for continuous indication, recording and automatic process control.

The instrument is intended for continuous measurements, and can therefore be installed as part of the control plant, functioning as a continuous detector, thus enabling closer and more immediate control of the process to be effected. It is described in an illustrated leaflet by Baird & Tatlock (London) Ltd.

Steel pipes for water, gas, sewage and air.

Stewarts & Lloyds Ltd. have issued a 204-page catalogue to replace one published in 1938. It gives full particulars of S. & L. steel pipes, together with extensive technical data. This revised edition has been called for largely because an amendment has been issued to British Standard 534, considerably reducing the number of sizes and thicknesses of steel pipes. The catalogue measures 8½ in. × 11 in., and is extremely well produced with stout covers.

Seaweed Processing Research

Work on the extraction of alginates from seaweed was started by the Institute of Seaweed Research early in 1953. Hitherto investigations have been confined to the lesser-known algal chemicals, since alginic acid was already being exploited commercially. It has become increasingly apparent, however, that the extraction and exploitation of all these chemicals are to a large extent interdependent. Consequently, it has been found necessary to obtain more data on the economics of alginate extraction. The work on alginates is described in the Institute's annual report for 1953. Other development work on algal chemical extraction processes has been continued, work has been done on the removal of water from seaweed, mainly by non-thermal means, and bulk samples of algal chemicals have been produced for extra-mural investigators.

Production of algal chemicals

WATER-INSOLUBLE Laminarin. A two-stage counterflow batch process for the extraction of water-insoluble laminarin, based on the laboratory process by Black *et al.* (*J. Appl. Chem.*, 1951, 1, 505), has been developed to a semi-technical scale. The size of starting material used in the small-scale laboratory work (milled to pass $\frac{1}{8}$ -in. mesh) was, on the larger scale, too fine for subsequent separation in a reasonable time. It was shown that material milled to pass an $\frac{1}{4}$ -in. screen gave a high degree of extraction with less filtration difficulty than when using finer or coarser materials, and this size was consequently adopted in the larger-scale investigations. Partly to compensate for the increased size, and partly to prevent premature precipitation of laminarin before the second stage extraction and clarification stages were complete, the reaction temperature was increased from that employed on the small scale (room temperature) to 40 to 60°C. A dilute acid-weed ratio of 4 or 5 : 1 was found to be the lowest practicable ratio consistent with reasonable efficiency.

The results of this work have been used in formulating a possible commercial-scale process and calculating the approximate cost of production.

Continuous Extraction Unit. Because of the advantages of continuous counter-current extraction, work is proceeding on the development of an extraction unit for this purpose. The experimental set-up, which is constructed in glass, consists essentially of a column down which the dried, milled weed gravitates against an upward stream of extracting fluid, the spent weed being discharged at the foot of the column and the extract near the top. The weed, fed by means of a small screw conveyor, is kept in suspension in the extracting liquor by a series of paddles and discs, and is drawn off at the base by a specially designed positive displacement pump. This pump, the screw conveyor and the paddles are operated by sliding vane oil motors to give the necessary fine degree of speed control.

Work on this unit to date has been confined to improving its mechanical operation, and several problems still require solution.

Alginate Acid. Satisfactory extractions

have been obtained by treating dried, milled weed with about three times the theoretical quantity of sodium carbonate at a temperature of 50°C. for a period of two hours, followed by dilution and filtration. The yield of alginate, about 85% of the theoretical, was proportional to the quantity of liquor filtered from the weed residue. This difficult filtration problem is being investigated in collaboration with various sections of the chemical plant industry.

L-fucose. The procedure of Black *et al.* (*J. Sci. Fd. Agric.*, 1953, 2, 85) was used to prepare a quantity of fucose for experimental purposes. Fucoidin was hydrolysed with dilute acid under pressure at 135°C. In this case it was found that hydrolysis at a lower temperature resulted in a product which could not be induced to crystallise. The hydrolysate was purified by treatment with alcohol and ion-exchange resins, and the fucose crystallised from alcohol. The yield was 30.8% overall of 97.7% purity. A second batch was prepared by direct hydrolysis of milled *Pelvetia canaliculata* following the method of Clark (*J. Biol. Chem.*, 1922, 54, 65). The fucose in this case could not be crystallised directly but was eventually obtained in 33% yield by formation of the phenyl hydrazone.

Hydroxyethyl Laminarin. The method of Black and Dewar (*J. Sci. Fd. Agric.*, in press) was followed to prepare 6 lb. of hydroxyethyl laminarin for use in extended clinical trials as a possible blood plasma substitute. The yield was 77-81% compared with 88% on the laboratory scale.

While the actual preparation presented no difficulty, the isolation and drying of this product proved to be troublesome.

Fundamental Study of Liquid-Solid Extraction. Mr. B. Macdonald, working under the direction of Professor P. D. Ritchie and Dr. T. J. Mitchell at the Royal Technical College, Glasgow, is studying the extraction of constituents from natural products such as seaweed. A diffusion apparatus has been designed and is being tested initially with porous earthenware slabs which are being used as artificial carrier solids.

Drying of seaweed

Thermal Drying. A commercial scale through circulation belt type drier has been

tested and its thermal efficiency calculated during a production run on littoral seaweed (80% *Ascophyllum nodosum*, 10% *Fucus vesiculosus* and 10% *F. serratus*). The evaporation rate, based on an observed production of 13 tons of about 14% moisture content, using a material of about 69% initial moisture content, was 4.050 B.Th.U./lb. water evaporated. This poor performance may be due to the employment of through-circulation drying with relatively shallow beds, giving a very small time of contact.

De-watering by Pressure. Several different types of conventional screw expeller were used to assess the possibility of expelling fluid from *Laminaria cloustoni* whole plants chopped into about 6-in. lengths, *L. cloustoni* stipe only and *L. cloustoni* frond only. The results indicated that stipe and frond together can be pressed to give about 50% weed and 50% fluid, but that all the fluid comes from the stipe. At the same time, in the machines tested, stipe alone caused choking from which it appears that the frond acts as a lubricant.

It should be appreciated, however, that the machines used were each designed for a specific material other than seaweed, and there is little doubt that modifications to the design would make them suitable for stipe alone from which significant quantities of fluid could be expressed. It does not appear that frond can be treated in this way with any hope of success.

De-watering by Plasmolysis. Further experiments have been carried out on the removal of water from *Laminaria* fronds by plasmolysis. In the original experiments, treatment with 35% sodium chloride for 10 min. removed about a third of the water originally present but doubled the ash content. Subsequent experiments, using a 10-min. 35% calcium chloride treatment, removed about half the water and increased the ash content by less than half.

A 10-min. water wash after the sodium chloride treatment put back all the water and gave a product of slightly lower ash content than the original. A similar wash after calcium chloride treatment put back only one-third of the water removed and gave a final ash content only half that of the original material.

(Concluded on page 211)

Manufacture of Paper from Straw and Bagasse

By A. E. Williams

Owing to the increase in the price of chemical wood pulp, much more use is being made of straw and bagasse for paper making. In the United Kingdom, for instance, it is calculated that 500,000 tons of paper could be made from the annual supply of home-produced straw. The processes involved in making paper from both straw and bagasse are outlined in this article.

IN recent years an impetus has been given to the use of both straw and bagasse for pulp production by the vastly increased price of chemical wood pulp. Purchases of this material from Canada are limited by the lack of dollars, while the forests of Sweden, Norway and Finland have practically approached their maximum economic yield. Against this, many areas of the world have available as virtually waste materials large quantities of both straw and bagasse. In the United Kingdom the greatest use of straw for this purpose was made during the last world war, when the peak consumption was around 350,000 tons p.a. The United Kingdom produces between 7 and 8 million tons of straw each year and, from this, after allowing for direct agricultural uses, there is about 1 million tons available each year for industry. With a 50% yield of pulp, this amount of straw would make 500,000 tons of paper each year.

As bagasse is the fibre left after extraction of sugar from the cane, the utilisation of this material is normally confined to those countries where the sugar cane is grown and extracted. An old established use for bagasse is as boiler fuel at the sugar mill, but in most cases when this demand has been fully met there is still a large surplus. To use this surplus, several of the world's largest sugar mills are at the moment installing pulping plant. Bagasse emerges from the crushing plant, which extracts the raw sugar, with about 45% moisture content and is usually carried on overhead conveyors directly to steam-raising furnaces. These boilers have in the past been deliberately built without any of the refinements that give a high efficiency, for the simple reason that the calorific content of the bagasse which was available for burning was greater than that required for steam-raising and the boilers were used as destructors. Thus a typical efficiency for these boilers would be about 55%, compared with about 80% for a modern coal-fired boiler. By modifying the design of the boiler, its efficiency may be increased, so using less bagasse for a given steam output and making available a larger quantity of bagasse for paper making. Of the original cane, the amount of residual fibre is about the same as the

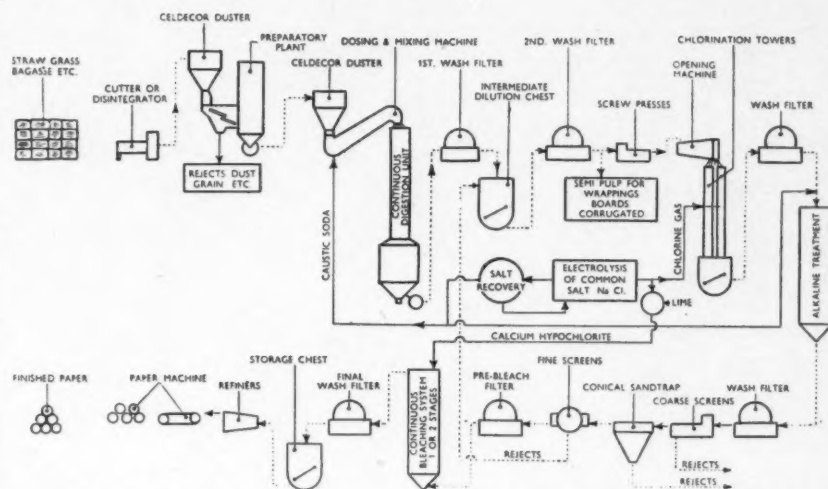


Fig. 1. Flow sheet showing the processing of straw and bagasse for paper making.

sugar content, about 14%. A raw-sugar mill using bagasse as boiler fuel should not need to burn more than 8% fibre on cane. Larger quantities of bagasse for pulping can be liberated by burning bagasse dry instead of wet. Burning bagasse in the dry state increases the boiler efficiency from 55% to about 67%, that is, by about 20%, so far as a reduction in bagasse consumed for the same heat energy. At some mills the total quantity of bagasse available is being reserved for pulping and the boilers are being changed over for coal or oil firing. Where substitution of coal or oil takes place, it follows that the prime cost of a ton of bagasse is the cost of an amount of coal or oil of equivalent calorific content. Wet bagasse of 45% moisture content has a calorific value of 4,500 B.Th.U./lb., against 8,300 B.Th.U. for dry bagasse. Thus 2.3 tons of steam are raised per ton of wet bagasse fired in a furnace of 55% efficiency, and usually about 7 tons of steam are raised from a ton of coal. Such are the economics which have to be considered at the sugar mills when contemplating pulp making.

Types of pulp

Pulps from straw and bagasse are very similar; the fibre dimensions are much

smaller than those of the softwoods largely used for wood pulp making, and finer and a little shorter than hardwood fibres. Pine or spruce fibres are 3 to 4 mm. long, while straw and bagasse are from 1 to 1.5 mm. This relative shortness of the fibres may be put to good advantage in making fine papers from bleached pulp. It imparts good appearance and strength, which can be obtained with wood pulp only by considerable beating or shortening of the fibres. The good sheet-forming characteristics are put to use by mixing straw or bagasse pulp with wood pulp, so reducing the amount of beating required for the wood. Such small fibres give a firm sheet of paper specially suitable for printing and writing papers. Bleached straw and bagasse pulp is being used in different parts of the world in almost every type of paper. While these pulps are versatile in application, they are less versatile than long-fibred wood pulps. Whilst wood pulps are naturally rather soft, they can make a firm sheet by suitable beating, but straw and bagasse pulps—which are naturally firm—cannot be made soft. For example, they are unsuited for the so-called featherweight printings which are characterised by exceptional bulkiness, or for blotting papers.

When compared with writing or print-

ing papers made from well-beaten wood pulp in which the fibre length has been reduced, the strength of straw or bagasse papers is good. However, while wood fibres may be shortened, straw or bagasse, which are already short, cannot impart the characteristics of long fibres, the most important characteristic of which is high tearing strength. Because of this, straw and bagasse alone is unsuited to the making of very strong wrapping papers, tough ledger papers or cement paper sacks. These pulps are very often used in such papers, but they are always reinforced with a long fibre pulp to fortify the tearing strength.

The compactness of sheet formation results in straw or bagasse papers being slightly more difficult to de-water and to dry on the paper-making cylinders. This feature only becomes apparent with high proportions of these pulps and may be allowed for in the design of the paper-making machine when it is known that it is to be used for such pulps. The known developments in straw and bagasse pulping methods do not suggest that newsprint will be made from these materials so as to compete economically with newsprint from wood. Ordinary newsprint contains about 83% of pulp prepared from logs by mechanical grinding, with a yield approaching 100%. No such method has been developed for straw and bagasse, for which chemical methods have to be used, with pulp yields nearer 50%.

Processing

Bagasse when compared with straw has an advantage in that very little preparation is required before it can be processed for pulping; the extraction of the sugar has already compressed and disintegrated the cane. The straw, however, has received no preliminary treatment and this has first to be cut and cleaned before passing to the pulping plant. The flow sheet, Fig. 1, shows the basic technique of processing. Preliminary treatment in the case of bagasse consists of placing the dried bagasse into a disintegrating machine where the unwanted material is separated as a dust by screening.

The cutting of straw into short lengths facilitates the removal of dust, grain, dirt, etc., makes it easy to convey automatically and enables it to be packed into the plant more compactly. In the straw-cutting machine, several rotary blades may be employed, the bale of straw being advanced by a band conveyor to grippers which feed it to the blades. The cut straw passes by means of an air current to a cleaning plant incorporating screens and air currents designed to remove as much as possible of the nodes, ears and dust. In the past, a feature which has prevented straw pulp from being a satisfactory substitute for normal pulping materials has been shive, and the removal in this plant of the nodes and ears which are the prime cause of shive has reduced this to a minimum.

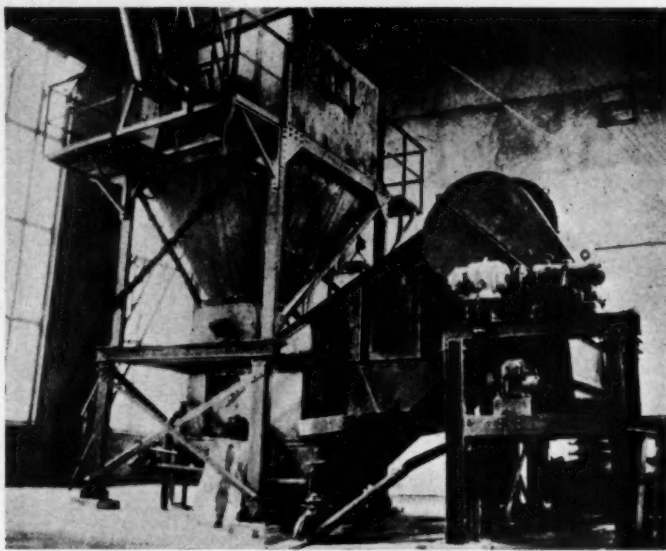
At the top of the cleaning plant, rotary blades dislodge the dust which is drawn away by suction fans. After dusting, the straw falls down a cyclone and through a rotary valve to a beating drum and thereafter on to two horizontal shaking screens. Rejects are removed on these two screens and fall below to the next unit. At the end of the second screen the straw is blown across an air gap into a central collecting shaft. Across the air gap, nodes and heavy particles separate and fall down to join the rejects from the shaking screens. A straw duster, dosing and mixing machine is seen in Fig. 2.

From the straw preparation plant the clean material is dropped into a mixing

Some towers in use are 45-ft. high, while others are 70 ft.; the extra length is obtained by adding one or more of the riveted circular sections to the tubular part of the tower. The average time required by the material to travel from the top to the bottom of the tower is 2 hr. On emerging at the base of the tower the material is in a semi-pulped condition and it is removed continuously to be diluted with hot water before passing to a vacuum washer, or filter.

Vacuum filter washing

One or more stages of vacuum filter washing are used, according to the requirements of the finished product. In a typical



[Cellulose Development Corporation Ltd.]

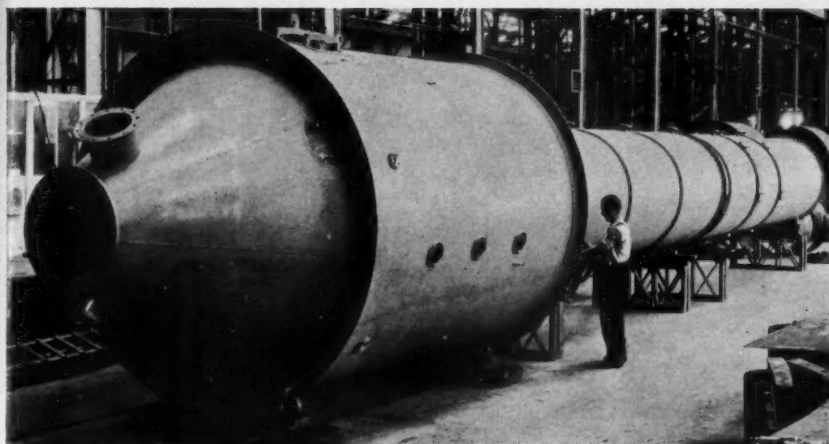
Fig. 2. Straw duster, dosing and mixing machine for the addition of caustic soda before cooking, showing feed to the top of the continuous tower.

vessel where the cooking chemical solution is added continuously. Based on the dry weight of the fibre, about 11% of caustic soda is taken up by the material at this stage. From this point the material, whether straw or bagasse, is treated in the same way. After impregnating with the dilute soda solution, a conveyor carries the material to the top of a cooking or digestion tower into which it is fed by a screw conveyor.

The digestion tower, Fig. 3, is fabricated from mild steel, the narrow tubular portion of the unit being heated by a series of steam jackets, and low-pressure steam is used in these to preserve the character of an atmospheric cooking process. Naturally the temperature of the material in the tower tends to increase the lower it gets, because of the hydrostatic head of material above it which gradually raises the temperature to over normal boiling point. The height of the tower depends upon the type of raw material being pulped and the rate of travel of the material through the tower can be controlled automatically.

rotary vacuum filter the drum rotates partially submerged in a bath of the material to be filtered, and the solids form on the surface of the drum which is under vacuum from the inside. The liquid portion is sucked through the filter medium to the inside of the drum, whence it is continuously discharged through automatic valves. Sprays of water may be applied to the material on the drum surface to assist in washing out impurities from the solids. The latter are removed from the drum surface by a scraper blade. The Celdecor-Paxman filters have been specially designed for filtering pulp and they have normal suction drums which may be fabricated in stainless steel, or rubber-covered, for handling corrosive material, or cast iron when the material is not corrosive. Only about one-third of the drum surface is immersed in the pulp, the remaining two-thirds being available for displacement washing. Rows of water sprays are fitted over the filter for this purpose.

The pulp from the filters is conveyed into a series of screw presses, Fig. 4, which



[Davey, Paxman & Co. Ltd.]

Fig. 3. Continuous digestion tower under construction.

take out a large proportion of the water. These screw presses are driven by an electric motor through vee ropes and worm reduction gears. Pressure in the presses can be varied by the movement of weights on a lever. Where a relatively coarse type of final product is to be manufactured, the pulp may proceed direct from the filters without pressing or further processing. Such materials as wallboard, corrugated and other wrapping materials often contain this semi-pulp. For the production of normal papers, however, the pulp has to be further refined and processed to take out colour and impurities and, in this case, the dewatered pulp is conveyed to an opening machine which opens up the pressed semi-pulp so as to present a larger surface area to the chlorine which is employed in bleaching it. The opened-up pulp is discharged directly from the opening machine into the chlorinating towers, which have a diameter of about 20 in., and the pulp travels slowly about 25 ft. through them. As the pulp descends the tower it is met by a stream of chlorine which is being blown in through inlets around the base. The gas velocity and the speed of travel of the pulp through the tower can be regulated to give any degree of bleaching required. Normally the pulp absorbs about 12% of chlorine based on the dry weight of the pulp.

Production of chlorine and caustic

The chlorine gas and also the caustic soda is produced simultaneously in electrolytic cells which operate on a solution of common salt, and this makes the pulp factory self-contained so far as chemicals are used in the processes. Common salt is a compound of sodium and chlorine and, when a current of suitable magnitude is passed through a solution of the salt, chlorine is liberated at the anode, while sodium is produced momentarily at the cathode, the sodium combining with the water in the salt solution to form caustic soda. Further processing of the bleached pulp involves washing, neutralising, filtering, screening, etc. These latter processes are varied according to the type of paper to be produced; the cheaper papers receive less processing than the superior qualities, which latter are naturally more costly although produced from the same raw material.

Types of straw

Since the establishment of this paper-making technique in Britain, the farmers are taking an interest in the supply of suitable straw to the pulping mills. While all cereal straws are suitable for paper making, some are slightly better than others, but all make good-quality papers. The cellulose content of the various cereal

straws varies slightly and average figures are as follows: rye 46%, wheat 45% and oats and barley about 40%. Thus, from the pulping point of view, rye and wheat straws are preferable in that they contain a higher proportion of potential pulp. In the rice-growing countries paper is being made from the rice straw and the paper used in the tobacco industry. Rice straw has the highest fibre length to width ratio and this gives strength in a very thin paper.

Seaweed Processing Research

(Concluded from page 208)

Algal chemistry

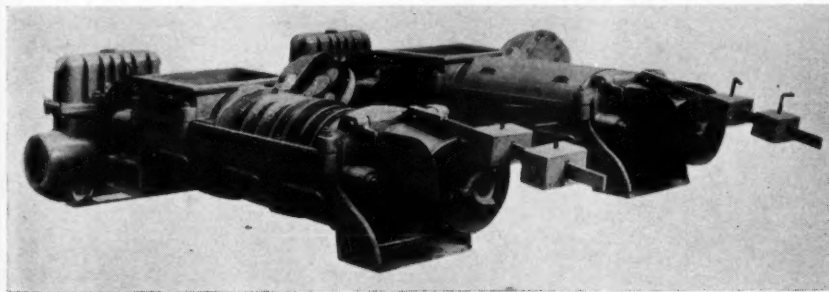
Work has continued, on the laboratory scale, on methods for the isolation of mannitol and the effect of solvents on the grade of alginic acid. Several derivatives, with promising results in the medical field, have been prepared from laminarin, while attempts have been made to prepare derivatives of fucoidin. Analytical methods have been worked out for the determination of galactose and other sugars in samples of algae and terrestrial plant material, and for the estimation of laminarin sulphate in blood and urine samples. Fundamental studies have continued on the chemical composition of laminarin and on the algal proteins, while work has been initiated, and some progress made, on the enzyme systems present in the algae. A preliminary study has also been made of the carbohydrates present in some of the green algae (Chlorophyceae).

Stewarts and Lloyds' half-century

In 1903 the union of A. & J. Stewart and Menzies Ltd. with Lloyd & Lloyd Ltd. brought under one control manufacturing plant capable of dealing with all classes of tubes from the smallest sizes up to 6 ft. in diameter. Stewarts & Lloyds Ltd. have published a 208-pp. book containing a lavishly illustrated commentary on the major events that have occurred within their organisation since that time, and the national and international background against which they have taken place.

The first chapters of the book contain a history of the company and its subsidiaries; this is followed by an account of the company's activities during World War II, including the part it played in the 'Pluto' pipeline operation in the English Channel. Further chapters describe the progress that has been made in recent years, and mention is made of the company's department of research and technical development. A special 48-pp. section illustrates the range of products made today. Finally, the company's activities in Australia, India, New Zealand, South Africa and Rhodesia are described.

The book is an impressive production which skilfully arouses interest in the company by relating its history to the tremendous events of the past half-century.



[Cellulose Development Corporation Ltd.]

Fig. 4. Screw presses for de-watering semi-pulp before treating with chlorine.

Slurry Pumping: Questions and Answers

DEAR SIR.—Having read Mr. Williams' article on Slurry Pumping and Pipe Line Design in your April issue with great interest, there are two points which I would like to raise:

(1) Mr. Williams enlarges his view that the critical pumping velocity is the most economic pumping velocity by saying that in a given case where the pumping velocity is below the critical velocity, an adjustment can be made by diluting the slurry.

I give below two instances where such a procedure would lead to poorer economy, and as these instances are by no means unusual, I have the feeling that an article on slurry pumping is incomplete without mentioning them.

(a) Generally speaking, the solid constituent of a slurry is the important part, the liquid merely serving as a 'carrier.' Thus for a given rate of solid transfer in say lb./min., the economy of pumping can be expressed in terms of the effort required to transfer 1 lb. of solid. Dilution of a slurry to attain critical pipe velocity will certainly decrease the effort required to transfer 1 gal. of slurry owing to the reduced friction head; but it may increase the effort required to transfer 1 lb. of solid, since the solid will be associated with a larger amount of liquid.

(b) In many instances, the reason for making a slurry is to handle a solid in a more convenient way, and at some stage in a sequence of operations the liquid may have to be removed. This removal becomes more costly as the amount of liquid present is increased and a point may be reached where the saving in pumping costs by slurry dilution is more than offset by the cost of removal of the extra liquid. Furthermore, the liquid itself (usually water) will cost something, and to be worthwhile the saving in pumping costs by slurry dilution must exceed the cost of the added liquid.

(2) Elsewhere in the article the view is expressed that slurries of the same solid concentration and with only slightly different chemical compositions may give friction head losses that vary by 300%. I would go further and say that slurries of identical solid concentration and identical chemical composition, but with varying particle size or shape distributions may give friction head losses that vary so greatly that one such slurry may behave as a near-Newtonian fluid whereas another may be so stiff as to be incapable of reasonable flow along a pipe.

J. R. Theobald

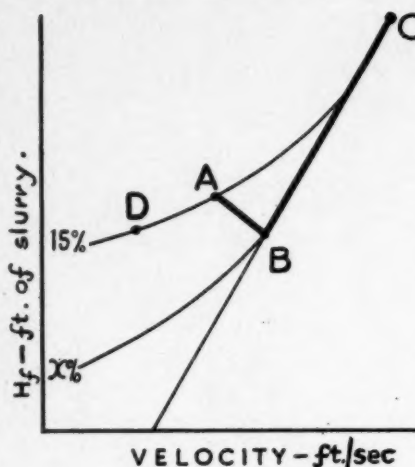
Mersey White Lead Co. Ltd., Warrington.

Author's reply

I should like to thank Mr. Theobald for showing such a keen interest in my article.

His first point briefly is that although a decrease may be achieved in friction head loss along the main by dilution, this may be outweighed by the increased energy required to pump the added fluid against any static lift of the pumping system, together with the difficulties in fluid removal at a later stage.

The point that has been overlooked, however, is the reason for dilution. With a settling slurry it is essential to pump under turbulent flow conditions to prevent sedimentation and to achieve this it is necessary, when the diameter of the pipeline is predetermined, to dilute.



Referring to Fig. 6 of my article, a given volume of a settling slurry of 15% solids concentration flowing in a pipe of diameter 'd' in. may be represented by the point 'D'. In order to pump under turbulent flow conditions dilution must be carried out. Between 'A' and 'B' laminar conditions of flow will prevail and between 'B' and 'C' turbulent flow conditions are achieved.

Point 'B' represents the most economic safe pumping velocity with a settling slurry on a continuous pumping basis. Once committed to slurry pumping, dilution in such a case is inevitable to prevent the possibility of tedious unplugging of long pipe runs. I should like to make a point here. The amount of sedimentation taking place is self-regulating by virtue of the fact that as the area of flow decreases the rate of flow will increase until turbulent conditions of flow are reached and no more sedimentation occurs.

With a non-settling slurry the economic pumping velocity will be largely determined by the ease with which the slurry can be fed into the slurry pump, possibly

represented by point 'D.' Recent developments in slurry pumps, particularly the Meader pump, present engineers with the means of pumping slurries thicker than hitherto.

Referring to the second point, inevitably a short article on slurry pumping cannot cover adequately every aspect of such a wide field. The object of the article was to outline a basic procedure for approaching a new slurry pumping problem. Particle size, of course, is most important. Generally the particle sizes in slurries to be handled by works engineers are predetermined, consequently the test main results would furnish sufficient information for the problem to be solved successfully.

Correlation of results with regard to particle size is most difficult. If an attempt is made to assign a characteristic dimension to a particle, two important difficulties arise:

- (i) How to determine experimentally the frequency distribution to a known degree of accuracy; and
- (ii) How to define an average particle diameter.

Many equations have been advanced in an attempt to express the viscosity of suspensions as a function of the volume concentration of the suspended material. In practice, however, these equations are impractical to apply, due to the difficulties outlined above and pumping experiments are most necessary.

B. G. Williams

Pollution control. A healthy trend in water-pollution-abatement laws is reported by the U.S. Manufacturing Chemists' Association in the third in its series of water-pollution-abatement manuals. The new manual, W-3, on 'Neutralisation of Acidic and Alkaline Plant Effluents,' indicates that the trend of late is toward a policy which takes into account not only the characteristics of plant effluents but also the capacity and potential use of the receiving water.

It is the purpose of manual W-3 to set forth a programme for neutralising industrial wastes. It describes laboratory and engineering studies to be undertaken before treating polluted water. General methods of treatment for acid effluents and the equipment required are indicated. Included is a table listing various alkalis to be used in neutralising acid effluents together with current market prices for these chemicals.

Two sections of W-3 are concerned with the process for neutralising alkaline effluents and include a description of insoluble sludges resulting from neutralisation. Safe practices to be followed in carrying out the process are indicated. Price 25 cents, from the M.C.A., 1625 Eye Street, N.W., Washington 6, U.S.A.

Manufacture of Fused Calcium-Magnesium Phosphate

IMPORTANT TRIALS IN NEW ZEALAND

From Our Own Correspondent

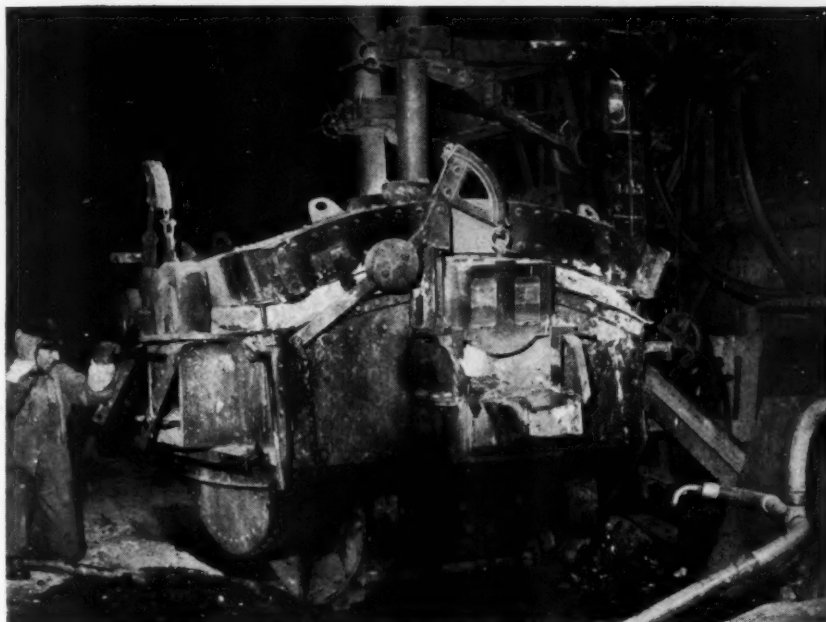
Research workers and technicians of the Chemical Engineering Section of the Dominion Laboratory (Department of Scientific and Industrial Research), Wellington, New Zealand, have recently produced in trial runs with a small pilot plant several tons of fused calcium-magnesium phosphate, to be used for field tests as a farm fertiliser. Since New Zealand has little or no indigenous sulphur sources, the success of this experiment is of great significance, since it shows the feasibility of manufacturing phosphatic fertilisers there without the use of imported raw materials other than phosphate rock.

CONTRARY to general belief, New Zealand's high farm productivity (the basis of her economy) does not depend on the 'natural fertility' of New Zealand soils. They are, in fact, generally deficient in plant-available phosphorus, and in many areas the calcium content, also, is low. Thus, to establish and maintain good pastures, extensive and continuous applications of artificial fertilisers—chiefly superphosphate—are needed.

For this reason, New Zealand has developed a substantial fertiliser industry, with a production capacity of approximately one million tons of superphosphate a year. But there are in the Dominion thousands of acres of low country yet to be developed, and millions of acres of low hill country now amenable to treatment by new techniques, *e.g.* aerial top-dressing. Furthermore, only a small amount of what may be termed the developed lands are at, or even near, the level of maximum possible production; so the demand in New Zealand for phosphatic fertilisers will undoubtedly increase.

It has been estimated that within twenty years, twice, or even thrice, the amount of fertiliser now being made there will be needed. Yet in the past decade, the local industry has been hard put to meet current demands. Root cause of the difficulty is the need to import raw materials—rock phosphate from Nauru and Ocean Island, sulphur from the United States. During World War II, Nauru and Ocean Islands fell into Japanese hands; supplies from alternative sources—Florida, Egypt, North Africa, Makatea and other Pacific Islands—proved inadequate, mainly on account of shipping shortages.

After the war, supplies were resumed from Nauru and Ocean Islands, on a scale commensurate with current and even future needs; but a world shortage of sulphur then developed. So the production in New Zealand of sulphuric acid (mainly by the box-type lead chamber process) as an integral part of the local fertiliser industry,



The pilot plant, formerly a steel furnace of the 'rocker' type, about to be rocked and tipped. The two 4-in. carbon electrodes can be seen above—the furnace hearth is the third electrode. The furnace uses 560 kva. of electric energy and holds between 15 cwt. and 1 ton of fused product.

suffered a serious check. While it is true that sulphur supplies have already become more plentiful—though considerably dearer—there is little ground for hope that allocations to the New Zealand fertiliser industry will allow for the expansion needed.

It should be noted also that New Zealand has practically no commercial deposits of elemental sulphur, on which the industry's present and planned facilities are based, and only small deposits of sulphur-bearing materials of a concentration greater than 40%. Certain thermal mud-flats there contain much larger quantities of sulphur-bearing material, of about 15% concentration, which elsewhere would not pay for exploitation. Those deposits, however, are

close to large quantities of natural boiling water, so their treatment by one of the newer processes (*e.g.* that of the Chemical Construction Corporation) may yet prove economic.

Nor has New Zealand any known commercial deposits of pyrites, gypsum or anhydrite. Large reserves of pyrites exist in Australia; but production there is small as yet, and likely to be absorbed, at least in the immediate future, by that country's own large pyrites-burning projects. Because of the elaborate gas purification systems needed, the cost of converting New Zealand's existing sulphuric acid plants to pyrites-burning would be very high (estimated overall at from £2,500,000 to

£3 million); the per ton cost of producing superphosphate would increase; and there would be no increase—in fact, a slight decrease—in the acid-production capacity.

An alternative would be to build new pyrites-burning plants, to supply concentrated acid to groups of existing phosphate-treatment plants. While this would increase New Zealand's acid-producing capacity, it would also be very costly; nor does it solve the basic problem of dependence on imported raw materials. For these reasons, then, chemists of the Department of Scientific and Industrial Research have for some years been investigating several processes for producing phosphatic fertilisers independent of sulphur.

After studying the situation in 1951, by arrangement between the governments of New Zealand and the United States (under the Smith-Mundt Act), Dr. G. L. Bridger of the Iowa State College, recommended, *inter alia*, that for further expansion of phosphate fertiliser production in New Zealand the fused calcium-magnesium phosphate process be used where a basic water-insoluble available product is needed. With the exception of rock phosphate, all the necessary materials for making this product are obtainable locally, while an adequate electric power potential is, or soon will be, available for the purpose.

The new process

This process was developed by the Tennessee Valley Authority and has been used on a commercial scale by two companies in the United States—the Manganese Products Corporation of Seattle, Washington, and the Permanente Metals Corporation, California. Japan produces now about 200,000 tons of phosphatic fertiliser annually by the same method, while its use in Formosa and Sweden has also been reported.

Materials consist of a mixture of rock phosphate and olivine or serpentine in the proportion of approximately 2 : 1. This is fused at about 1,500°C. in an electric furnace and poured while being rapidly water-quenched. Quenching granulates the product, which is then dried and used without further curing. Pulverisation may follow; but since one-fifth of all fertiliser delivered to New Zealand farmers is now distributed from the air, and the granulated product appears specially suited to that purpose, some grinding, at any rate, can be dispensed with. American concerns using the fusion process first calcine the serpentine, but the Japanese do not. Bridger suggests that olivine, which has a low volatile content and therefore does not require calcination, is preferable to serpentine.

There are in New Zealand some very large deposits of magnesium silicate materials, such as dunite, which consists of about 90% olivine and contains 48% MgO and 39% SiO₂. These deposits are centrally situated and easily accessible. One North Island reserve of serpentine (in the Te Kuiti district) is estimated to contain about



Fused calcium-magnesium phosphate being poured in a molten state from the electric furnace. Note the stream of water for sudden quenching to keep product in glassy form and prevent crystallisation with consequent reversion to a form unavailable to plants.

1,250,000 tons of material of 32-36% MgO content. Another serpentine deposit at Mossburn, in the South Island, is well placed for the supply of material to a fusion-process plant which may be established in that region. Silica, used as flux in the process, occurs plentifully in the form of sand, gravel, and quartzite rock, throughout both islands.

With American methods of manufacture, silica is not added separately, since it occurs as an impurity in the comparatively low-grade pebble-phosphate (of about 30% P₂O₅) generally used there. Using the higher-grade Nauru rock-phosphate (P₂O₅ approx. 40%), New Zealand experimenters found that extra silica, beyond the amount already present in the magnesium silicate of the charge, was needed to obtain the required ratio, silica to MgO, of at least 3 : 2 by weight. Other additions, now being made experimentally in the New Zealand process, are small quantities of 'trace' elements known to be greatly beneficial to certain types of soil.

Though generally short on minerals other than rock, New Zealand does have quite large coal deposits, suitable for coking, mainly on the west coast of the South Island. There about 1 million tons a year are being produced. Proved reserves of coking coal in this region are assessed at 18 million tons, plus 31 million tons classed as probable, and 40 million tons inferred. There is also a large hydro-electric potential in New Zealand, estimated at about 1.25 million kw. in the North Island, and more than 5 million kw. in the South Island, both on a 50% load factor basis. A further source of energy exists in the thermal steam reserves now being harnessed in the Wairakei area of the North Island.

Dr. Bridger suggests, in a Report submitted to the New Zealand Government,

that plants producing 240 tons a day might be established economically at Bluff and Whangarei—near the extremities of the South and North Islands respectively—since these are in areas likely to use increasing amounts of fertiliser, and are some distance from existing fertiliser plants. A plant established in the southern region could presumably draw upon supplies of serpentine now being mined at Mossburn, while a northern plant could be placed in direct contact by rail with the Te Kuiti serpentine deposits. Moreover, Bluff and Whangarei are well-found seaports, so dunite (olivine) from the Nelson deposits—located near the coast, and about midway between the two ports—could also be shipped direct.

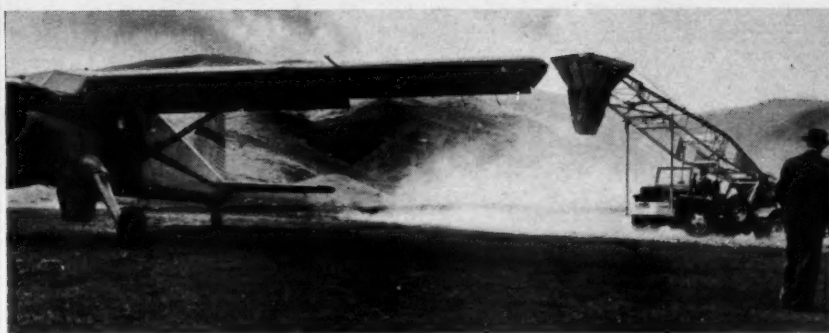
Costs

To gauge the economic possibilities of the new process, Dr. Bridger made two cost-estimates, one relating to the present methods used in the New Zealand fertiliser industry, the other for a fused calcium-magnesium phosphate plant turning out a product of equivalent available P₂O₅ content. In the former case he estimated the cost of producing superphosphate in a hypothetical new plant of 100,000 tons per year capacity using elemental sulphur at its then price of £18 15s. per ton. In view of the high cost of lead it was assumed that a contact sulphuric acid plant would be used. Cost of the plant was estimated at about £500,000, with £158,000 needed as working capital (the value of two months' production of product before depreciation), giving a total capital requirement of £658,000. Depreciation was allowed at 7½% per annum; interest charges on capital investment, 6% per annum.

The basis for comparison was the final cost of a ton of available P₂O₅ delivered to the farmer. Delivery and other costs stated are the local ones then ruling, and manufacturer's and retailer's profits have not been included. An average railage of 60 miles from plant to farm is assumed, and an average truckage of six miles from railhead to farm.

For costing the manufacture of fused calcium-magnesium phosphate the estimate was made for a plant producing 240 tons a day, or 80,000 tons a year, located at either Bluff or Whangarei. Annual requirements would be 10,000 kw. electricity, 56,000 tons phosphate rock, and 28,000 tons olivine. It was assumed that olivine from the Nelson area could be delivered to either plant at an all-in cost of £5 per ton. Capital requirements would be about £600,000 for plant construction, plus £164,000 as working capital, giving a total of £764,000. A plant of such size would ensure reasonably low production costs, but one of half that capacity need not be ruled out as an economic proposition.

It will be seen that the estimated production cost of a ton of available P₂O₅, whether at the plant or delivered to the farmer, was only slightly higher than for



This photograph illustrates the 'wind-drift' of superphosphate as manufactured in New Zealand today. Use of the granular, fused calcium-magnesium phosphate would avoid this, it is claimed. The mechanical loader (right) has just discharged its load, about 1 ton, into the hopper of the aircraft, which is about to take off and discharge its load on hilly farmland. Two-thirds of New Zealand is either hilly or mountainous and aerial methods of farmland management are rapidly catching on.

Table 1. Estimated Production Cost of Superphosphate in a New Plant by Present Process
(Capacity, 100,000 tons per year of 20% available P_2O_5 product)

	Estimated cost per ton of superphosphate
	£ s. d.
Rock phosphate, 0.57 tons at £6 11s.	3 15 0
Sulphur, 0.114 tons at £18 15s.	2 2 7
Nitrate of soda	4 5
Manufacturing cost	1 5 0
Bags, 12 at 3s. 7d. each	2 3 0
Cost at plant before depreciation	9 10 0
Depreciation, 7½% of £500,000	7 6
Interest on capital investment, 6% of £658,000	7 11
Total cost at plant	10 5 5
Railage and truckage to farm	1 6 0
Total cost at farm	11 11 5
Total cost at farm per ton of available P_2O_5	£57 17 1

Table 2. Estimated Production Cost of Fused Calcium-Magnesium Phosphate
(Capacity, 80,000 tons per year of 24% available P_2O_5 product)

	Estimated cost per ton of fused product
	£ s. d.
Phosphate rock, 0.70 tons at £6 11s.	4 12 0
Olivine, 0.35 tons at £5	1 15 0
Electricity, 925 kwh. at 0.5d.	1 18 6
Electrodes (graphite), 8 lb. at 2s.	16 0
Coal, 37 lb. at £5 per ton	1 8
Operating labour, 0.9 man-hours at 8s.	7 2
Supervisor's salary, one at £2,000 per year	6
Repairs and maintenance:	
Labour, 0.3 man-hours at 8s.	2 5
Materials	5 0
Water, 1,000 gal. at 2d. per 1,000 gal.	2
Miscellaneous other supplies, services and overheads	5 0
Bags, 12 at 3s. 7d. each	2 3 0
Cost at plant before depreciation	12 6 5
Depreciation, 7½% of £600,000	11 3
Interest on capital investment, 6% of £764,000	11 6
Total cost at plant	13 9 2
Railage and truckage to farm	1 6 0
Total cost at farm	£14 15 2
Total cost at farm per ton of available P_2O_5	£61 10 0

superphosphate as normally manufactured in New Zealand; and the gap will probably diminish, or disappear entirely, as the price of sulphur advances.

For New Zealand, the use of a fused calcium-magnesium phosphate fertiliser would have some distinct advantages, beyond the strategic and economic ones derived from dispensing with the need to import sulphur. In field trials carried out by the Department of Agriculture over a number of years, this type of fertiliser has shown a significantly greater response than any other used. Its alkaline properties would make it more beneficial than superphosphate on 'sour' soils, while its water-insolubility renders it more readily adaptable to high-rainfall areas. For the same reason, the fused product in granular form can be transported in open trucks, and stock-piled in the open. When bagged it does not cake, nor does it cause bag-rot, even after grinding.

When finely pulverised, the fused calcium-magnesium phosphate is highly soluble in 2% citric acid, so its phosphorus pentoxide content is readily available to plants. The need for fine grinding, however, is open to some doubt, and there have been conflicting reports on this aspect. Tests on pastures in the Marton Experimental Area, undertaken by the New Zealand Department of Agriculture, have shown good response from the granular product in preliminary assessments; the Permanente product was sold for direct application without grinding; while extensive tests by the Tennessee Valley Authority of fused tricalcium phosphate—a similar product—showed that the coarse (-6 mesh) product gave as good a response as the pulverised.

The point is important, as it affects production costs. Bridger's Table 2 allows for pulverisation. The advantages of bulk handling, well known in New Zealand, as elsewhere, would also accrue, if the product proved generally efficacious in granular form. Bagging—a costly item—could then be largely dispensed with. In aerial distribution (a practice growing rapidly in New Zealand) there would be less loss through wind-drift, more accurate placement, and a saving on the need for labour, store-buildings, and other facilities at the airstrips.

Though new to New Zealand, the fused calcium-magnesium phosphate process is in a good stage of development elsewhere, and it involves no technological risks. The small pilot plant used in the local experiments was adapted without difficulty by technicians of the New Zealand Department of Scientific and Industrial Research, and installed in the Railways Department workshops at Woburn, near Wellington. No unforeseen problems arose in either the construction or the operation of the pilot plant, and the test results were consistent and predictable. There seems to be no obstacle in the way of commercial exploitation of the process in New Zealand.

Bulk Transport of Liquid Sulphur

BRITISH FIRMS CO-OPERATE IN FIRST REGULAR BULK DELIVERY OUTSIDE U.S.A.

BULK delivery of liquid sulphur by Broad has been initiated between Shell's Stanlow chemical plant and Brotherton & Co. Ltd., of Bromborough, Cheshire.

When sulphur became available in liquid form at Stanlow it was realised that it would be advantageous both to Shell and to the customers if it could be delivered in this form instead of being allowed to cool to rock sulphur which has frequently to be melted again before processing. Stanlow sulphur is produced at a purity of over 99.9% and, no matter how carefully the operation of solidifying, digging out and transporting the solid sulphur in lorries and rail wagons to customers' premises is carried out, there is always the danger of contamination either by moisture or extraneous matter, which would lead to subsequent processing difficulties. The same dangers, of course, are also bound to arise in customers' storage. The transport of liquid sulphur of a high degree of purity in vehicles designed specifically for this purpose effectively prevents any contamination between manufacturing point and customer.

Apart from this advantage, a definite saving can be effected in reheating costs and the cost of suitable equipment for storage of molten sulphur is offset by lower handling costs and economy in space.

From the point of view of both manufacturer and user, the handling of a friable material such as pure rock sulphur has created a difficult dust problem. Corrosion of nearby plant can result from scattering of this dust, particularly during windy weather, and the physical loss of sulphur to dust can in the course of time reach appreciable amounts.

A number of very interesting technical difficulties have had to be overcome at the production point, in the bulk delivery vehicle and at the customer's plant. That these difficulties appear to have been solved is due to the enthusiastic co-operation of the three companies concerned: Shell Chemical Manufacturing Co., the manufacturers; Harold Wood & Sons Ltd., the bulk vehicle operators; and Brotherton & Co. Ltd., the consumers.

Storage and handling problems

At Stanlow, sulphur is produced by burning H_2S in a plant based on the Claus kiln process and, although the level of conversion is very high, traces of H_2S are present in the sulphur product which can give rise to pyrophoric iron on the internal surfaces of the liquid-sulphur storage tanks. To prevent the spontaneous ignition of this pyrophoric iron and consequent risk of tank explosions, oxygen must be excluded by the maintenance of an inert-gas blanket



Loading operations at Stanlow: standing by to start flow of sulphur from storage tank to tanker. Operator observes that inert gas pressure is sufficient to prevent admission of air to storage tank during loading.

(This and other two photographs by Shell)

over the surface of the sulphur in the tank.

The bulk liquid sulphur storage installation at Stanlow consists of two 180-ton mild-steel storage tanks lagged and provided with steam coils. To allow trouble-free discharge of these tanks, it is essential to maintain the liquid sulphur in them at a temperature within the range of 140 to 150°C.; this point is illustrated by the viscosity data for sulphur shown below. At this relatively high temperature, vehicle loading by pump presented many problems and therefore the tanks are elevated to allow the vehicle to be loaded by gravity.

Temperature (°C.)	Viscosity (centipoises)
123	10.94
135.5	8.66
149.5	7.09
158.2	7.59
160	22.8
165	500.0
184	1,600.0

The melting point of sulphur is approximately 113°C. and it can be seen, therefore, that the working range of temperature for bulk handling is not more than 40°C.

Transport

In considering the design of a suitable road tank vehicle the factors mentioned above had to be taken into account and three possible methods considered, namely:

- (1) The use of a mild-steel tanker under

a nitrogen blanket and discharged by compressed nitrogen.

- (2) The aluminium metallising of a mild-steel tank so that pyrophoric iron could not be formed, and the use of compressed air to discharge the load.
- (3) Mechanical pumping, which was ruled out due to the possibility of the sulphur cooling and blocking the pumps.

The method adopted was as outlined in (2) above, and is giving every satisfaction.

Harold Wood & Sons Ltd., the transport contractors who undertook the task, decided that the most practical way of tackling the problem was to use a heavily insulated steam-coiled tanker which would be unloaded by compressed air supplied by the air compressor mounted in the chassis and driven off the engine. As Brotherton in particular required discharge into an overhead storage tank it was decided that there should be discharge outlets both at the top and the bottom of the tanker. In order to meet these demands it was necessary to design the steam-heating arrangements very carefully.

In the original steam-heating system the jacket of the top delivery cock, the jacket round the stack pipe, the steam coils in the tank and gravity outlet and the jacket of the bottom outlet cock were all linked in series. Due to its considerable length, vibration and temperature variations caused fractures in this pipe, and it was therefore



Tanker in position for loading. Connection has been made to steam pipes for heating tanker outlet. In the background are the heated storage tanks.



Tanker driver connecting steam-heated tanker outlet to storage inlet at the Bromborough (Cheshire) plant of Brotherton & Co. Ltd.

decided to supply steam to each unit of the heating system separately. This method has worked extremely successfully in practice, connection being made to steam supply immediately prior to loading and again before unloading to ensure that the internal outlet stack pipe is free of solid sulphur.

Despite insulation, a skin of sulphur forms on the internal tank wall surface as the load cools, but this skin itself provides additional insulation and it does not build up progressively with each load. Slight temperature variations affect the thickness of the skin, but it normally amounts to 4 to 5 cwt. at most. The pay load of the tanker is 13 tons.

Overhead storage tank

The loaded road tanker is driven into Brotherton's process building, where overhead bulk storage of liquid sulphur is arranged in a horizontal cylindrical storage tank which is carried on a steel supporting structure and is of about 70 tons capacity. The vessel is heavily insulated and fitted with internal steam coils which serve to maintain the sulphur in liquid form.

Provision is made for electrical heating of the storage tank during holiday periods and at other times when the plant is closed down and no heating steam is available. Provision is also made for venting the tank to atmosphere via a vertical stack pipe. A level gauge is fitted which indicates the quantity of liquid sulphur in the tank, and other fittings are two steam-jacketed cocks, one on the tank bottom to serve as a drain and the other at the end of the tank leading to the steam-heated liquid sulphur draw-off main which supplies four sulphur burners.

The steam-heating system is again

brought into action during discharge. The actual discharge of the liquid from the tanker is through a steam-jacketed overhead pipeline specially designed and spring loaded in order to give the maximum flexibility. Pressure (15 p.s.i.) is provided by the pump mounted on the tanker chassis.

The storage installation is intended for supplying liquid sulphur to four 'Glen Falls'-type rotary sulphur burners which were originally designed for burning rock sulphur.

The liquid sulphur is ultimately introduced into the burners through special

heat- and corrosion-resisting steel fittings to withstand the burner conditions.

The delivery run from Stanlow to Brothertons at Bromborough is approximately seven miles and takes about 20 min.; the whole operation from loading to discharging takes less than two hours. Experience gained in the successful organisation of this comparatively short haul makes it clear that deliveries over far greater distances are unlikely to present any difficulties which could not be overcome. In the meantime, that experience is being embodied in the design of a new tanker.

The Manufacture of High-strength Hydrogen Peroxide

THE commercial production of solutions of high-strength hydrogen peroxide is undoubtedly a most interesting development, since it might be said to offer a new chemical product to industry, opening up possibilities of entirely new applications, of which perhaps the power unit is an outstanding example. The description 'high strength' normally applies to solutions exceeding 75% by weight, although at the present time the highest strength actually manufactured is 90 to 92% by weight.

Improved methods of manufacture and corresponding improvements in purity and stability suggested some years ago the feasibility of commercial production of high-strength solutions, but there were no industrial uses to encourage this development. The position changed, however, during the war, when the high-strength material was used in a number of military weapons, one authority actually quoting 26 such applications during that time.

It is now known that the Germans started manufacturing an 80% w/w solution in 1939. This was followed by production in both this country and the United States, where plants have operated for several years.

The hydrogen peroxide vapours obtained by the hydrolysis of persulphate solutions from the electrochemical process are too dilute to allow direct fractionation to the 80 to 90% product. Such vapours also contain traces of entrained electrolyte and, since purity is of major importance for high-strength material, the subsequent product would be unsatisfactory.

The manufacture of the concentrated solution is, therefore, based on the 30 to 35% hydrogen peroxide obtained directly from the electrochemical process. The procedure has been described in a monograph by W. S. Wood, B.Sc., A.M.I.Chem.E., F.R.I.C., and published by the Royal Institute of Chemistry. Briefly, the process is as follows:

The commercial product is introduced through a valve into the vaporiser, which may be a steam-jacketed tube. The hydro-

gen peroxide vapours together with non-evaporated liquor enter the packed column separator. The non-evaporated liquor returns through a pipe and mixes with feed peroxide, so that ultimately conditions are established whereby the strength of hydrogen peroxide vapour entering the separator is equal to the strength of the feed solution. The impurities in the system are removed either continuously or semi-continuously through a valve, whilst the vapours leaving the separator pass into a packed fractionating column, which is supplied with reflux water and attached to a condenser. Hydrogen peroxide is condensed from the vapour in the fractionating column and run off through a valve, or passed to a second distillation system to be subjected to a similar distillation. Water vapour is taken off as overhead product through the condenser.

It is usual to have two distillation stages to make 80 to 90% hydrogen peroxide, the product in the first stage being approximately 70% by weight. Control of the purity of the solution in the second evaporator cycle can also be effected by periodic or continuous bleed-off from a valve. The distillation is carried out at low pressures of the order of 40 mm. mercury, and appropriate conditions are specified to ensure safety in the system.

The final product may be said to have the same degree of purity as an analytical reagent, and it is worthy of note that the purity of the solutions has led to the introduction of physical methods for controlling the process. For example, the refractometer is used in place of the permanganate burette to determine concentration; the potentiometer in place of the alkali burette to determine acidity, and conductivity measurements may be used instead of a whole series of chemical analyses to check purity.

The conditions for operating this process have now been well established and the high-strength product is handled in bulk tonnages and transported and stored for long periods of time in large aluminium tanks.

New Distillation Column Packing Designed at Harwell

WIDE APPLICATIONS TO INDUSTRY ENVISAGED

A NEW distillation column packing has been developed at the Atomic Energy Research Establishment, Harwell, primarily for the large-scale separation of the hydrogen isotopes by the distillation of water. Owing to the comparatively low value of the separation factor for this system (1.026 at 100°C.) the primary requirements were a very large throughput, H.E.T.P. values of the order of 2 ft. or less and a low first cost. The new packing, which has tentatively been named *Spraypak*, fully meets these requirements and shows promise of wide application in industry.

It is a surprising fact that distillation, undoubtedly the most important of the unit processes of chemical engineering today, is still carried out to a very large extent using bubble cap trays, which were first introduced more than 100 years ago. However, within the last few years a number of new types of distillation and absorption column fillings¹ have been developed with the object of overcoming the inherent limitations of conventional packed and bubble plate columns. Some of these comprise modified forms of the bubble cap plate and perforated plate trays, designed to overcome inherent limitations such as the restricted throughput. Others, such as the *Turbogrid*,² the Kittell expanded metal tray,³ and *Panapak*, a multi-layer expanded metal packing developed by Scofield,⁴ are simpler in that downcomers for the liquid are avoided, and a perforated grid, either flat or corrugated, is employed to produce a dense spray at regular intervals throughout the column. This spray serves the double function of providing a large surface for efficient contacting between vapour and liquid phases, and of making the system inherently self-distributing. It is probable that these fillings will show little or no diameter effect, i.e. reduction in efficiency with increasing column diameter.

Spraypak is a novel form of the latter type of contact device and consists of a cellular structure made for most purposes from commercial $\frac{1}{8}$ -in. nominal mesh 20 to 24 s.w.g. expanded metal of $\frac{1}{8}$ -in. strand width. An example of a typical pack, fitted within a 2-ft.-diam. transparent column, is shown in Fig. 1. The walls of each cell comprise separate Z-shaped pieces bolted, welded or clipped together to form a packing unit which is installed through the top of the column. Modified forms of construction are at present under consideration which will be suitable for installation through the manholes of conventional tower shells.

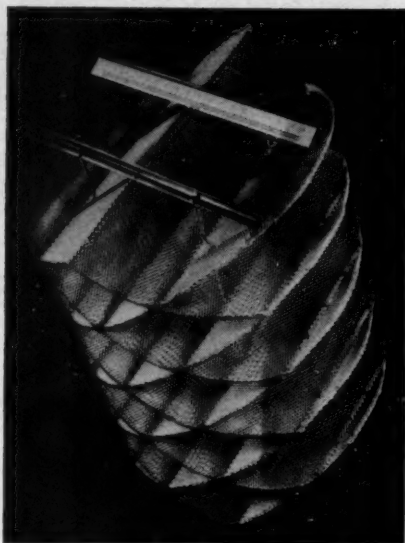


Fig. 1. Sample of 'Spraypak.' The ruler measures 18 in.

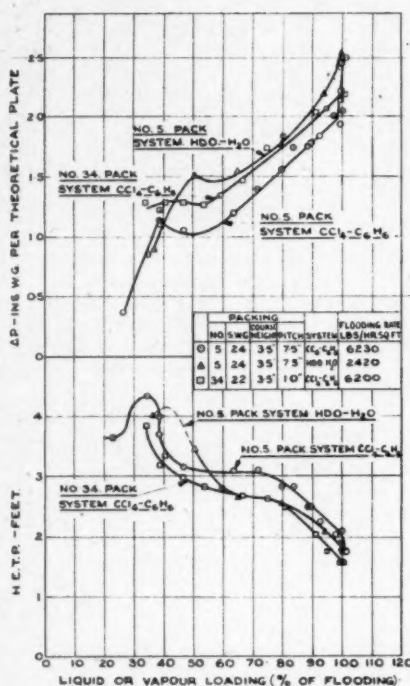


Fig. 2. H.E.T.P. and pressure drop data for Nos. 5 and 34 'Spraypak' at total reflux.

Investigations of the effect of variations in the type of mesh used and in the geometry of the packing have been carried out in a transparent air-water rig with a cross-section of 15 in. \times 27 in. and a packed height of 4 ft. Distillation tests have been carried out in an M.S. rectangular column of the same cross-section with a packed height of 20 ft., using as test systems water slightly enriched in isotopic content, and also benzene-carbon tetrachloride. Air-water tests are also being carried out in a large air-water rig with a cross-section of 2 ft. 6 in. \times 7 ft. 6 in. and a packed height of 10 ft.

Experimental results to date show that the throughput is some 200 to 250% of that of a well-designed bubble cap column with 18-in. plate spacing; thus the flooding rate for the steam-water system is of the order of 2,500 lb./hr./sq. ft. at atmospheric pressure. Typical H.E.T.P. and pressure drop data obtained with early forms of the packing are shown in Fig. 2. It will be noted that the curves of H.E.T.P. against throughput show a plateau in the range from about 50 to 80% of flooding, so that the packing possesses a flexibility approaching that of the bubble cap tray.

At present it is not possible to assess accurately the cost of the packing as installed, since in any case this will to some extent be a function of the type of construction adopted. However, present indications are that the cost will be some one-third to one-half of that of bubble cap trays for the same duty.

A licence to manufacture *Spraypak* in the U.S.A. has been granted to Denholme Inc., New York.

REFERENCES

- ¹Oil and Gas Journal, 1954, April 26, 152.
- ²Chem. Eng. Prog., 1954, 50, 57.
- ³Chem. Eng. 1953, 60, No. 4, 242.
- ⁴Chem. Eng. Prog., 1950, 46, 405.

Turbo exhausters and blowers. The applications, constructional details and capacity range of Sturtevant Engineering Co.'s turbo exhausters and blowers are illustrated in a new 8-pp. pamphlet. These machines are made for applications requiring vacuum from 2 to 10 in. mercury or air pressure from 1 to 6 p.s.i. A chart shows the range of volumes. Among the items illustrated are a multi-stage turbo exhauster in a large pneumatic conveying plant handling limestone and dolomite; a multi-stage gas booster; and a direct-coupled multi-stage turbo blower for gas-producer service.

Plant and Equipment

Flame-proof motors

The recently introduced range of *Neco* Buxton-certified flameproof motors and geared motors are made for three-phase and two-phase voltages from $\frac{1}{4}$ to 3 h.p. for ungeared, and to 2 h.p. for geared, motors. The speeds available extend (on 50-cycle circuits) from 26 to 2,800 r.p.m. The motors are certified by the Ministry of Fuel and Power for all three gas groups, and are therefore suitable for all industrial applications where inflammable vapours are present, as well as for use in coal mines.

Geared motors have two, three or more stages of spur reduction gearing running on ball bearings in an oil bath, with the final shaft and motor shaft in line. Installation is greatly simplified since the bolting plan and final shaft centre height are the same for all speeds, horsepowers and voltages, and the machine is adaptable for mounting in any previously specified position. Both the geared and the ungeared types are available for flange mounting in addition to the normal foot-mounted pattern. Makers are Normand Electrical Co. Ltd.

Distillation trays

Turbogrid distillation trays are a new type of vapour-liquid contacting tray for distillation processes in the petroleum refinery, chemical and petrochemical industries, particularly where high or increased throughput is required. Metal Propellers Ltd. are now making 2½-ft.-diam. trays in Monel. These are the first trays of the new design which Metal Propellers have made under licence from Shell.

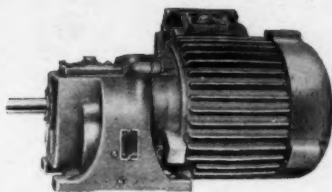
Turbogrid trays are the result of a 20 years' research programme on distillation equipment undertaken by Shell research laboratories. The performance of these trays has been proved in many different installations in both refinery and chemical plant service, and they are being specified for a large proportion of Shell's new and replacement installations.

The trays are a new development of particular interest to the chemical industry. They should offer new possibilities for starting improved or new processes, and for reducing costs in existing processes to meet the ever-increasing competition from overseas.

Safety tilter for carboys

Equipment for the safe pouring of acids from carboys has been developed by Powell & Co.

This tilter is in the form of a cradle designed with a dropped base so that the bottom of the carboy lies within a circular retaining ring. The sliding clamp attached to the tilting handle rests firmly upon the



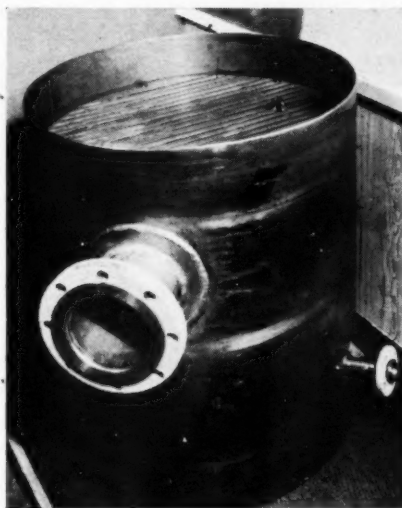
Geared flameproof motor, certified by the Ministry of Fuel and Power for all three gas groups, and suitable for all industrial applications where inflammable vapours are present.

top of the glass bottle (from which it is insulated by heavy-gauge rubber tubing) and the clamp does not touch the iron skip or hamper at all. By this means the usual metal ring surrounding the neck of the bottle (which so often corrodes, and may cause fracture of the glass neck during cold weather) is done away with. Thus there is also uninterrupted access to the neck of the bottle when pouring, so reducing danger of spilling it is claimed. As an additional precaution, two 'rigid' prongs project downwards from the clamp over and beyond the outside of the carboy.

The usual chain or hinged bar across the front of the carboy (which so often corrode away) are made unnecessary.

When the carboy has been placed in the dropped base of the cradle and the sliding clamp has been lowered into position, it is virtually impossible, it is claimed, for the bottle or carboy to fall from the stand, however far over they are tilted.

This new safety device is made from



A section of a 2½ ft. diameter Monel fractionating column which, when complete, will contain forty of the new Shell Turbogrid distillation trays which Metal Propellers Ltd. are now making under licence. The tray shown is made of Monel bars with slots of calculated length, width and number.

tubular steel and the sliding clamp has powerful jaws that do not damage the handle. It is finished with two coats of anti-corrosive paint.

A typical model, SCT/22 (for 22-in.-diam. carboys), has the following dimensions: height, including handle, 64 in.; width, 28 in.; weight, 54 lb.

Silent accelerator for central heating

The *Thermopak* accelerator for use with forced-circulation central-heating systems is claimed to be absolutely silent in operation and to require no maintenance. It is glandless and a single shaft serves both motor and accelerator. The smallness and compactness of the unit enables it to be fitted into any pipe layout. Small accelerators with 1-in. and 1½-in. branch sizes are connected with unions, the larger sizes being flanged for belting into the pipe-work. The *Thermopak* can be fitted in horizontal or vertical pipework, provided that the shaft of the accelerator is in the horizontal position.

The complete unit is made up of a single- or three-phase electric motor which does not cause any disturbances in radio reception, and of a pump designed so as to obtain a high output while at the same time offering little resistance to the passage of the water when the *Thermopak* accelerator is stopped. There is no stuffing box.

The entire rotating element, including the electric motor, is separated completely from the stator and windings by a shell of non-magnetic metal. The bearings, very widely dimensioned and made of stainless steel and bronze, are lubricated by circulation of the water and do not require any other lubrication. The bearings are not located in the main circuit, but are lubricated by water drawn off from the circuit along the shaft of the unit. Sigmund Pumps Ltd. are the makers.

New steam traps

A new inverted-bucket-type steam trap, the *IB*, has been developed by Spirax-Sarco Ltd. A notable feature, common to all sizes of the trap, is that the bucket, bucket arm and valve (all of stainless steel, as is the valve seat) are a single unit. A particularly important innovation is that at no point is this operating unit attached to anything (no pins or pivots) but is quite free.

Three sizes are available, each in three pressure ranges as follows (the maximum discharge capacities for hot condensate, in lb./hr., are in brackets):

Half-inch size: *IB*-1 up to 200 p.s.i. (560); *IB*-2 up to 120 p.s.i. (880); *IB*-3 up to 60 p.s.i. (1,090).

Three-quarter-inch size: *IB*-1 up to 200 p.s.i. (1,400); *IB*-2 up to 120 p.s.i. (1,840); *IB*-3 up to 60 p.s.i. (1,900).

One-inch size: *IB*-1 up to 200 p.s.i.

(2,700); IB-2 up to 120 p.s.i. (3,020); IB-3 up to 60 p.s.i. (3,000).

The cover and case (of malleable iron) are bolted together. Another feature is that nothing is attached to the cover: when the cover is taken off, the internal assembly can be lifted straight out in one piece. Thus full maintenance is possible without taking the trap out of the pipeline.

Each size of trap has alternative straight connections (inlet and outlet in a straight line) or angle connections. The price is stated to be very reasonable.

Another recent development has been the redesigning of the Ogden open-top bucket steam traps. An internal feature prevents air binding, and the traps are designed so as to be easily tapped for an automatic air-vent connection where rapid discharge of air is necessary.

The $\frac{1}{2}$ -in., $\frac{3}{4}$ -in. and 1-in. sizes are non-lever patterns and the $1\frac{1}{2}$ -in. and 2-in. sizes are lever patterns. All the valve operating parts are of stainless steel; covers and bodies (of the standard product) are of cast iron. Each size of trap is available in three pressure ranges, and the following are the maximum discharge capacities (in all cases, these are for hot condensate):

For pressures up to 200 p.s.i.: $\frac{1}{2}$ -in., 555 lb./hr.; $\frac{3}{4}$ -in., 800 lb./hr.; 1-in., 3,200 lb./hr.; $1\frac{1}{2}$ -in., 7,100 lb./hr.; 2-in., 22,500 lb./hr.

For pressures up to 120 p.s.i.: $\frac{1}{2}$ -in., 880 lb./hr.; $\frac{3}{4}$ -in., 1,120 lb./hr.; 1-in., 3,450 lb./hr.; $1\frac{1}{2}$ -in., 9,200 lb./hr.; 2-in., 29,800 lb./hr.

For pressures up to 60 p.s.i.: $\frac{1}{2}$ -in., 1,090 lb./hr.; $\frac{3}{4}$ -in., 1,370 lb./hr.; 1-in., 4,200 lb./hr.; $1\frac{1}{2}$ -in., 9,000 lb./hr.; 2-in., 30,150 lb./hr.

Mould drying development

A new, portable, gas-fired unit for drying casting moulds has been developed by the Heaton Foundry Co. Ltd. with the initial aim of eliminating the necessity for a hot-air fan. It was also felt desirable that provision should be made for safeguarding against gas or electricity failure in view of the frequent operation of this type of equipment for long periods without attendance. The unit is primarily a refractory-lined chamber in which gas from a *Hypact* burner is burned in the large volume of air provided by an electrically operated fan mounted on top of the drier.

The air is controlled by a graduated butterfly valve which when in the 'off' position allows a by-pass of air sufficient to ensure complete combustion of the maximum gas flow.

The gas is governed by a standard gas governor, and a Perl No. 60 magnetic valve is fitted, the magnetic valve of which is activated by the electricity supply to the fan motor, and if this fails the gas supply is cut off. A Perl thermo-magnetic flame-failure device is incorporated in the weep from the above valve and thus, in the event



A decarbonising tower 11 ft. 6 in. diam. \times 50 ft. long and weighing 130 tons being dispatched as deck cargo on the S.S. Rhexinor from Glasgow for the new Kurnell plant of the Australian Oil Refinery Ltd. (Caltex associates). Manufactured by Babcock & Wilcox Ltd. at Renfrew to the design of Foster Wheeler Ltd., this will form an important part of the propane decarbonising unit.

of gas or electrical failure, gas is cut off and will remain so until the correct lighting-up procedure has been re-instituted. It has been found in practice that drying times can be reduced by 40 to 50% compared with solid-fuel-fired units. Moulds are dried continuously and uniformly without any local overheating as is experienced with solid fuel. The moulds remain free from foreign matter and thus casting can be carried out immediately after drying.

The drier was shown on the Gas Council's stand at the B.I.F., Birmingham.

Acid-proof ventilators

An axial-flow acid-proof stoneware wall ventilator for the removal of corrosive and harmful gases from chemical works, laboratories, etc., is being made by the German firm Deutsche Steinzeugwarenfabrik.

The ventilator model SL is constructed according to aerodynamic principles, and the three-phase motor is completely stoneware-caged. There are three sizes available, with an output of 700 to 3,850 cu.ft./min. running at a speed of 1,400 and 2,850 r.p.m. All parts in contact with the fumes are impervious to acids and alkalis, it is claimed. The impeller is made of special

corundum stoneware and is fixed directly to the motor shaft. For the removal of explosive gases, special explosion-proof motors are provided. The fans can be installed either horizontally or vertically into wall or pipeline.

The ventilator is supplied ready for use. It can be dismantled for repair or overhaul without disturbing the pipe main.

U.K. agents for the ventilators are Anderman & Co. Ltd., London.

Automatic boiler

A self-contained, automatically controlled boiler of the American 'packaged' type suitable for oil, gas or oil/gas firing is now being marketed in Britain by G. W. B. Furnaces Ltd., under the name *Power-master*. These horizontal fire tube units have three-pass gas travel and are available in Models 15-500, giving steam outputs from 517 to 17,250 lb./hr.

In the oil-fired type, the heating system consists of a *Voriflow* air atomising oil burner which is claimed to give consistently clean combustion over loads of from 20 to 100%.

Fuel oil flows through the central tube of the burner and is picked up at multiple injection points by individual air streams. Only about 1% of the total full load combustion air is admitted with the oil for atomisation, which ensures a high efficiency during light loads.

Low oil pressure is required—well under 20 p.s.i. The burner can handle oils with 31 secs. Redwood to 3,500 secs. viscosity and over, it is claimed.

The *Voriflow* gas burner is of the pre-mix design. The gas flows through the central nozzle from the gas plenum while, at the same time, combustion air from the blower enters the air plenum, automatically controlled by the motor-operated damper. Primary pre-mixing air is directed through holes into the gas nozzle against venturi-shaped baffles. The outer secondary air ring controls the quantity of secondary combustion air admitted to the combustion chamber.

The boiler has a full-range combustion modulation control system which is said to ensure a high degree of running efficiency. This control is governed either by a pressure switch in the case of steam-raising boilers, or by means of a thermostat for water heaters. The adjustable cam positions for the fuel valve and air shutter are pre-set, after preliminary checking, for the correct flue gas analysis.

The boiler is claimed to be smoke-free. A forced-draught fan is incorporated on every boiler which necessitates only a simple vent pipe for fume exhaust. It is easily accessible for cleaning and maintenance.

The complete unit, including burner equipment, automatic controls and safety devices, is delivered mounted on a strong steel base and can be put into immediate operation.

For further information
about the Plant and
Equipment described, use
the coupon on page 226

World News

GREAT BRITAIN

Scottish group for Inst. Chemical Engineers

A Scottish group of the Institution of Chemical Engineers was formed at a meeting held in Glasgow on June 11 and attended by chemical engineers from all the main Scottish centres. The chair was taken by Dr. W. W. Cumming, former Professor of Technical Chemistry in the Royal Technical College, and among the principal speakers was Sir Harold Hartley, President of the Institution.

Dr. Cumming said that the first British university degrees in chemical engineering had been introduced at Glasgow University, but there were still too few graduates taking the course to meet the needs of industry. Some effort might be made to see whether the more popular technical chemistry degree might be merged or the courses modified and perhaps combined to meet the growing demands from the chemical engineering industry for graduates. Sir Harold outlined the important part which chemical engineers had to play as practitioners of the fourth major technology. In the development of food technology and atomic energy especially, there was a definite place for the chemical engineer.

New maleic anhydride plant planned by Monsanto

Monsanto Chemicals Ltd. announces that it is shortly to begin construction of a major plant to manufacture maleic anhydride by direct oxidation of benzene.

Monsanto, the only producer for sale of this important chemical raw material in Great Britain, has hitherto obtained it as a by-product. The new installation will be built specifically for the production of maleic anhydride and its output should be sufficient to cater for all the known needs of industry in Great Britain.

The new plant, which will be built at the company's Ruabon, North Wales, factory, is part of the continuous programme of expansion which has been carried out at this location since the war, and on which some £5 million has already been spent.

Maleic anhydride is a basic industrial chemical which is used as a raw material for the manufacture of alkyd and polyester resins employed in the paint and plastics industries, and as a starting point for various important organic syntheses.

Canadian firm bought by D. & C. and Wm. Press

Mr. Gordon Roach and Mr. Montague Holbein of D. & C. and William Press Ltd. have concluded the purchase of the old established Canadian business of Ross-Meagher Ltd., civil engineers and building contractors. Ross-Meagher will now exploit the gas pipe laying and other techniques in which the purchasers specialise.

Chair of Textile Technology

A new Chair of Textile Technology in the Department of Textile Industries at Leeds University, to be instituted from October 1, will be in addition to the existing Chair of Textile Industries (Prof. J. B. Speakman) and the Research Chair of Wool Textile Engineering (Prof. A. H. Nissan), and its institution is associated with plans for the development of the new building for the study of rayon and synthetic fibres. The appointed Professor of Textile Technology is Dr. C. S. Whewell, at present Reader in Textile Finishing at the University.

New petrochemical project

British Petroleum Chemicals Ltd. have decided to proceed with the erection of a new chemical plant at their works at Grangemouth, Scotland. Part of the raw material for the new plant will be drawn from the adjacent refinery of Grangemouth Petroleum Refinery Ltd. The plant will produce alkylate, an industrial raw material of the type used in the manufacture of high-grade detergents. The new plant is expected to come into production during the latter half of 1955.

British Petroleum Chemicals Ltd. is jointly owned by Anglo-Iranian Oil Co. Ltd. and the Distillers Co. Ltd.; Grangemouth Petroleum Refinery Ltd. is a wholly-owned subsidiary of Anglo-Iranian Oil Co. Ltd.

British Oxygen's increased sales of industrial gases

Aided by a substantial recovery in the general level of activity in the plastics industry, the British Oxygen Co.'s production of melamine is now established on a satisfactory basis and has further promise for the future, said the chairman of the company in his annual review. The intermediate product, dicyandiamide, has also been satisfactory, not only as the raw material for melamine manufacture but as an item having its own special market. Another interesting product, vinyl pyrrolidone, whose manufacture is novel in the U.K., continues to play a useful part.

Rare gases. The use of argon for welding non-ferrous metals and certain difficult-to-weld alloy steels has been extended by the introduction of new processes. As expected, sales have been at a much increased level, enabling the company to continue steadily to reduce the price, thus encouraging still wider use.

The other rare gases: neon, helium, krypton and xenon, have also made a favourable showing, although their sale remains relatively small. For the first time nitrogen has this year reached the stage of being sold in bulk in liquid form.

Tonnage oxygen. The continued active growth of interest in the bulk supply of

oxygen for use in the production of iron and steel and other primary materials has led the company, after development work extending over several years, to regroup its activities in this field. The 'tonnage' supply required must usually be met from a production unit costing with buildings and services as much as £500,000, matched for technical advantage to the particular project and linked for economic reasons with existing supply resources. Such plant units must be prepared individually for their specific purposes. This makes for a preponderance of technical and design work. The activities of the company's Plant Sales Department are integrated with the plant shops and production facilities of British Oxygen Engineering Ltd. at Edmonton, where the company constructs its own production plants, including the largest high-purity oxygen plants in Europe and specialty gas separation plants for customers in many countries.

Unilever spent £1 million on new detergent plants

Last year Unilever pushed their synthetic detergent sales to a new record—1,311,000 tons, compared with 1,217,000 tons in 1952. This was reported by Sir Geoffrey Heyworth, Unilever's chairman, in his review of the year. Outstanding sales increases were recorded in France, Germany, Austria, Denmark, Canada, South Africa, Nigeria, Malaya and Indonesia, the report states.

To keep pace with the increasing number of new synthetics placed on the market, nearly £1 million was laid aside for the development of detergent projects in 1953. These were: extension to Toronto plant, £250,000; additional plant at Aubervilliers, France, £345,000; additional plant at Harburg, Germany, £123,000; plant for soap and synthetic detergent powders in Vienna, £163,000.

New metals factory

A new factory at Crawley, Sussex, to be occupied by the Metals Division of the Telegraph Construction & Maintenance Co. Ltd., covers 8½ acres and will provide a floor area of 120 sq. ft. An illustrated booklet issued with the annual report and accounts features this and other new facilities of the company.

For some time past the company's premises at Greenwich have been found insufficient to cope with rapidly expanding activities, and it was decided to transfer the Metals Division to the new industrial estate at Crawley, where it will have ample room for further development. Work on this project is well under way and it is anticipated that the move will be completed by the end of 1954, when much-needed accommodation will be left available for further expansion at Greenwich.

The Farnborough factory has been improved and modernised for the Plastics Division which moved there from Greenwich during the year.

★ PERSONAL PARAGRAPHS ★

★ **Mr. S. A. Slack**, general manager of Bradley Pulverizer Co. and well known to the company's clients at home and overseas, has been appointed managing director. He succeeds **Mr. W. J. Fackerell**, who has resigned, but who will continue to act in a consultant capacity subject to call.

★ **Mr. P. J. C. Bovill**, an assistant managing director and a local director of Newton, Chambers & Co. Ltd. and general manager of its Chemicals Branch, has been appointed a county magistrate in the West Riding. He was educated at Cheltenham College and he qualified in fuel technology at Sheffield University. He came to Thorncliffe in 1922, entered the service of Thorncliffe Coal Distillation Ltd. (then newly formed) and became, in 1941, general manager of the Chemicals Branch.

★ **Sir Hugh Beaver**, M.I.Chem.E., has been appointed chairman of the Advisory Council for Scientific and Industrial Research in succession to Prof. Sir Ian Heilbron, F.R.S., who retires on September 30, 1954, on completion of his term of office. The Advisory Council for Scientific

and Industrial Research is composed of persons eminent in industry and science. Its task is to advise the Lord President of the Council on the policy and activities of the D.S.I.R. Sir Hugh Beaver, who has been a member of the Advisory Council since 1952, is managing director of Arthur Guinness, Son & Co. Ltd.

★ **Mr. L. R. Meek** has been appointed manager of the Gas Department of Henry Balfour & Co. Ltd. in succession to **Mr. A. C. Bureau**, who is now director and general manager of Balfour Lecoq Ltd.

★ **Mr. M. E. O'K. Trowbridge**, A.M.I.Chem.E., has been appointed general sales manager of Sharples Centrifuges Ltd. He has recently returned from a tour of the company's extensive operations in the U.S.A., where he has made a study of recent developments in separational techniques.

★ **Mr. E. L. Streatfield**, M.I.Chem.E., has joined the board of Houseman & Thompson Ltd. For the time being he will operate from the company's branch office in London.

Sir H. Hartley on the future pattern of science and industry

The fact that the problems of the transfer of mass and energy in chemical engineering were beginning to attract the attention of applied mathematicians was a hopeful sign, said Sir Harold Hartley, F.R.S., president of the Institution of Chemical Engineers, giving the first Fawley Foundation Lecture at Southampton recently. He said it was unfortunate that there has been a serious neglect of classical physics, which is the foundation of so much engineering, and this neglect, unless redressed, would be a serious handicap in the future.

Sources of energy. The whole 'energy picture' had been changed by the future possibilities of atomic power, and clearly there would be no world shortage by the year 2000, although its availability might well determine where development took place. The consumption of oil and natural gas was rising rapidly, while coal was almost stationary. But the coal reserves were much greater than oil and it might be that by then the world's needs of liquid fuel would be partly met by oil from shale or coal, petroleum being kept for special purposes.

Metal economies. Referring to metals, Sir Harold forecast an increased recovery of scrap with other economies, and intensive research for new ore deposits, new methods of metallurgy, and increasing emphasis on conservation. With the great industrial expansion would come increased use of electronic controls and a rapid growth in the newer industries, such as plastics, based so largely on research.

But with this growing emphasis on research what would happen to the vast number of smaller firms which could not afford to spend large sums in this way? 'They must specialise in the know-how of two or three new developments, which they can exploit,' he said.

'Gas' gallery for Science Museum

A new gallery devoted to the history of gas manufacture, its distribution and its by-products up to the present day represents the first collective effort by an industry on behalf of the permanent collections at the Science Museum, South Kensington, London.

The display occupies a gallery of some 5,000 sq. ft. in a newly finished wing of the museum and has been organised by a committee of the Institution of Gas Engineers upon which the Gas Council, various manufacturing interests and the Science Museum are represented. The gallery, which is executed in a modern and attractive style, illustrates not only the beginnings of the making of gas, first for lighting and then for heating, and its industrial uses but also the later uses of the many by-products of coal created through the gas-making process. It is designed to interest both layman and expert.

I.C.I. spends £7½ million on research and development

In 1953, a year in which sales reached the all-time record of nearly £282 million, Imperial Chemical Industries spent £30 million on new construction, making a total expenditure of £156 million on new fixed assets since the end of the war; spent £7½ million on research and development, roughly 3% of turnover; and increased the number of employees by 1,500 to make a total of 107,650, of which 77,400 are operatives and the rest staff.

These facts are given in the annual report for the year issued on May 21, together with details of the company's profit-sharing scheme for employees.

Research and development. Most of the arrears of technological work have now been dealt with and the company is doing more exploratory work. Two techniques being studied are the use of extremely high pressures and irradiation by radioactive waste materials from nuclear power plants. A special high-pressure laboratory has been erected at Billingham.

The pioneer plant for making glycerin by fermentation of molasses has yielded a product of excellent quality and enough information has been obtained to allow the design of a full-scale plant.

Considerable research has been undertaken on titanium in order to provide essential data for the design and construction of the large plant due to start up next year. Because argon is needed for titanium manufacture, supplies are to be extracted from the synthesis gas at Billingham works.

Experiments to compare the effect of nitrogen fertilisers applied to grassland in

solution by spraying and in the usual solid form have proved neither method to be more effective than the other. The scheme for extracting potash from the deep deposits at Whitby, Yorks, is temporarily at a standstill pending the result of efforts to get more finance and technical assistance.

Shell-moulding award

The development on a production basis of the shell-moulding method of making foundry moulds and cores has increased enormously the connections between the foundry and plastics industries, since it is dependent on the supply by the latter of efficient binding resins. The resin manufacturers have from the beginning played an active part in the development of the process and carried out a large amount of valuable research into the problems involved in their own laboratories.

A tribute to this contribution has been paid by the recent award of the first prize in the Jubilee essay competition of the Institute of British Foundrymen to Mr. D. F. Bailey, a member of the research and development department of Bakelite Ltd., for his essay on shell moulding. He is in charge of an experimental foundry at Bakelite's Birmingham works, in which is carried out development work on the use of synthetic resins in the foundry industry, and demonstrations of the shell-moulding process are also given. Before joining Bakelite he had 12 years' experience in the foundries industry, and is now senior vice-president of the Coventry Section of the Institute of British Foundrymen. In addition to the national award, his entry was awarded the first prize of the Birmingham Branch of the Institute.

First heavy-water atomic reactor

A new reactor which is being built at the Atomic Energy Research Establishment, Harwell, will be the fourth pile to be constructed at the establishment and the first in Britain using heavy water as a moderator. The moderator is the material used to slow down the speed of neutrons, the atomic particles released in the core of a reactor.

For the last six years Harwell has had available two piles, 'Bepo' and 'Gleep.' They have been used for research in a very wide range of subjects. In particular they have been used for work carried out in connection with the design of the plutonium-producing piles now in operation at Windscale and the newer nuclear energy electricity generating station now under construction at Calder Hall. However, the more advanced types of power pile to which Harwell is now giving detailed consideration are likely to operate at a much higher intensity than has been the case previously and this should lead eventually to a reduction of capital costs and lower overall costs of reactor operation.

Accordingly it has been decided to build at Harwell, in addition to the Zero-Energy Fast-Fission reactor (which has been operating for some months), a small research reactor operating at a very high intensity to permit the necessary experimental studies to be carried out. Besides fulfilling this function the new pile will make it possible to produce certain radioactive isotopes such as cobalt 60 which cannot be made with sufficient specific activity in 'Bepo.' Until now 'Bepo' and the Windscale piles have been the main source of the radioactive isotopes in which A.E.R.E. has a large international business.

The use of heavy water as a moderator enables the required facilities to be obtained at a lower capital cost than would be possible with a graphite-moderated system. The reactor will use as fuel highly enriched uranium, which will be supplied from the diffusion plant operated by the Atomic Energy Industrial Group at Capenhurst.

General design of the new pile is being undertaken by the A.E.R.E., whilst detailed design and provision of reactor components will be a responsibility of Head Wrightson Processes Ltd. The Ministry of Works are undertaking civil and general mechanical work in connection with site services, building and installation.

New pipe-making development

By a change of name which indicates the wider field of special ferrous and non-ferrous metal production in which it will be engaged, Sheepbridge Steel Castings Ltd., of Sutton-in-Ashfield, Notts, now becomes Sheepbridge Alloy Castings Ltd.

An entirely new bronze foundry is being developed at Sutton for the production of special non-ferrous alloys. Another new development is the production of long-length tubes centrifugally cast in special metals. By means of a patented process,

The Leonard Hill Technical Group—July

Corrosion Technology—Corrosion in Relation to Welding; Corrosion Inhibitors; Corrosion of Aluminium Cable Sheathing; Paint versus Corrosion, 2; Cuttings Fluids and Corrosion; Corrosion-resistant Materials of Construction in Radioactive Waste Disposal; Anti-corrosive Paint Tests in Belgium; Corrosion and Tablet Machinery.

Manufacturing Chemist—New Method of Testing Antiseptics; Ointment Bases, 2; Organic Microanalysis; Liquorice Root Processing; Benzyl Alcohol; Progress Report: Fertilisers.

Paint Manufacture—The Chemistry of Metallic Soaps; Carbon Blacks for Protective Coatings; The Application of Soaps in the Paint Industry; Conophor Oil.

Food Manufacture—Gelatin—From Raw Material to Finished Product; Progress with Quaternary Ammonium Compounds; Pilot Plant Production of a Milk Substitute from Groundnuts; The Manufacture of Active Dried Yeast.

World Crops—Mechanical Handling, 2; Natural Factors and their Influences on Tea Production; Trials with Systemic Insecticides on Hops; The Cocoa Industry in Nigeria, the British Cameroons and French Cameroons, 1.

Fibres—New Horizons for Fibrous Raw Materials for Paper Manufacture; New Zealand's £6½-million Paper Plant; Fibre Building Boards; Bonded Fibre Fabrics.

Building Materials Digest—Architectural Bronzes; Timber Identification; Stone for the Rebuilding of Cities, 4; Glass in Building, 1.

Muck Shifter—Engineering Developments in Central Africa; Giant Hydraulic Pipe Line Dredge.

Petroleum—Bulk Oil Storage; Trends in Modern Viscometry, 2; Petroleum Chemical Processes, 1; Oil in South Africa; Petroleum Additives, 2.

Atomics—The Determination of the Energy of Proton Gamma Resonances and their use to Check Theories of Nuclear Structure, 2; Comparison of Isotopes for use in Multi-Curie Therapy Sources; Use of Halogen-Quenched G-M Counters with Quenching Probes.

the Sutton plant can produce, in long lengths, centri-cast pipes and tubes in low- or high-alloy steels of the stainless or heat-resisting types; or, for example, piping consisting of a mild-steel exterior lined with a stainless-steel interior, or conversely a mild-steel pipe with an exterior surface of heat-resisting steel.

The range of application of this new Sheepbridge development extends from large cylinder liners for marine diesel engines to stainless-steel radiant tubes for the furnace industry.

The company state that, by the new process, the ability to produce bi-metal or composite tubes often enables a physical structure to be created having characteristics impossible to reproduce in a single-metal alloy by present-day known metallurgical processes, thereby making available, in effect, an added range of metals.

Booklet lists British equipment approved for Canada

It has been the custom of the British Standards Institute/Canadian Standards Association Approvals Agency to supply lists of electrically operated equipment manufactured in the U.K. and approved by the Canadian Standards Association with addresses of the makers of the equipment. As the number has increased considerably over the last 12 months, it has become impracticable for them to issue duplicated lists and the information has now been prepared in the form of a booklet, which also includes the names and addresses of the Canadian representatives.

This booklet contains the names of the manufacturers who obtained approval before March 31, 1954, and supplementary lists will be issued at six-monthly intervals—September 1 and March 1—each year. Further copies of the booklet and, when available, supplementary lists can be obtained free of charge from the B.S.I./CSA Approvals Agency, 2 Park Street London, W.1.

New office

Increased business and the resulting expanding factory requirements have compelled Honeywell-Brown Ltd. to establish an additional Glasgow office at 26 Blythswood Square, Glasgow.

Mr. D. J. Venning has been appointed district supervisor in charge of the office.

Newton Chambers' progress in 1953

The trading operations of Newton, Chambers & Co. Ltd. are to be concentrated into three production divisions under three assistant managing directors: Mr. P. J. C. Bovill (chemicals division), Mr. S. C. Tyrrell (excavator division) and Mr. K. E. Walker (engineering division, comprising the heavy construction and light castings departments). This was stated in the chairman's annual review for 1953.

Mr. Bovill and Mr. Tyrrell are both well known, not only for the parts they have played at Thorncliffe (where the company's head office and works are situated) but in their respective spheres at national level. Mr. K. E. Walker, who joined the company on January 1, is an engineer and metallurgist by profession and brings with him wide experience of the iron founding and allied industries.

Engineering Division (Heavy Construction). Although steel, particularly steel plate, was in short supply throughout 1953, production was maintained at a high level. Higher costs resulting from various national wages awards during the year, and only partially recoverable on contracts for which orders were taken more than a year ago, slightly reduced profits in some sections. The order book still provides assured employment for months ahead in most sections and the total profit was almost equal to the all-time record of the previous year.

Chemicals Division. Sales turnover was

maintained at the previous record level in spite of reduced prices for paper which the company has passed on to its customers. The division surpassed the record profit of last year despite difficulties of supply.

Change of address

Following its expansion, the London organisation of Rhodes, Brydon & Youatt Ltd. has moved to larger premises at 76 Victoria Street, Westminster, S.W.1 (telephone: Victoria 0068/9).

Sulphuric acid consumption

U.K. consumption of sulphuric acid and oleum in the first three months of this year amounted to 534,264 tons. The largest quantity, 137,125 tons, was used in the manufacture of superphosphates. The manufacture of sulphate of ammonia took 76,214 tons; titanium oxide, 51,121 tons; and dyestuff and intermediates, 21,817 tons. Other chemical trade uses were: hydrochloric acid, 15,765 tons; soap, glycerin and detergents, 10,563 tons; sulphates of copper, nickel, etc., 5,772 tons; bromine, 5,235 tons; drugs and fine chemicals, 4,231 tons; hydrofluoric acid, 3,527 tons; vegetable oils, 2,574 tons; bichromate and chromic acid, 1,970 tons; sulphate of magnesium, 1,344 tons; and phosphates (industrial), 417 tons.

New London offices for D.C.L. group

During the last fortnight in May most of the divisions and subsidiary companies in the D.C.L. Industrial Group moved from their former London offices to new accommodation in Devonshire House, W.1. The new address: Devonshire House, Mayfair Place, Piccadilly, London, W.1 (telephone: MAYfair 8867), is now common to the London offices of:

British Geon Ltd.
British Industrial Solvents.
British Petroleum Chemicals Ltd.
British Resin Products Ltd.
The Carbon Dioxide Co.
Commercial Solvents (G.B.) Ltd.
D.C.L. Engineering Division (Southern Office).
D.C.L. Industrial Alcohol Division.
D.C.L. Transport Department.
D.C.L. Industrial Group Publicity Dept.
D.C.L. Yeast and Malt Extract Dept.
The Distillers Co. (Biochemicals) Ltd.
F. A. Hughes & Co. Ltd.
Honeywell & Stein Ltd.
The Methyating Co. Ltd.

Associated with these changes, Magnuson Elektron Ltd. have moved to Distillers House, 20/21 St. James's Square, S.W.1 (telephone: WHitehall 1040).

The telegraphic addresses of the various units remain unchanged.

The D.C.L. entrance to Devonshire House is in Mayfair Place and not in Piccadilly.

INDIA

New fertiliser plants for Sindri

The Government of India has decided to set up an ammonium nitrate plant and urea plant at Sindri. Two firms from Germany, one from the U.S. and one from Italy have responded to the Government's invitation to submit tenders for their construction.

PORTUGAL

Power deficiency reduces fertiliser output

The annual reports for 1953 of the Uniao Fabril do Azoto and of Amoniaco Portugues give details of time lost through lack of electric power supplies. In 1953 the Uniao Fabril's factory at Alferrarede worked for 210 days and produced 19,328 tons of sulphate of ammonia (as against 22,221 in 1952); the Amoniaco Portugues factory at Estarreja worked for 175 days and produced 14,543 tons (as against 20,983 in 1952). Confidence is expressed that production in 1954 will be up to 50% higher in view of recent instructions issued by the Ministry of Economy regarding the allocation of electric power. Amoniaco Portugues has increased its electrolytic hydrogen plant and is planning to instal a plant for the manufacture of hydrogen from producer gas.

SPAIN

Synthetic rubber project

A business group in Barcelona is considering plans for setting up a pilot plant to manufacture synthetic rubber on an alcohol basis, according to unconfirmed reports. There are ample supplies of industrial alcohol available in Spain. The reports say that the plant, as planned, would have an annual capacity of 8,000 tons.

GERMANY

Chemical engineering Congress

The Congress of the European Federation for Chemical Engineering for 1955 will take place in Frankfurt-am-Main during May 14-21, 1955, on the occasion of the Achema XI Chemical Apparatus and Equipment Exhibition and Congress. Nineteen technical and scientific societies from 11 European countries will be represented at the congress, the preparatory work in connection with which is being undertaken by the Dechema organisation. Scientific discoveries and technical developments in the chemical engineering field will be described in a series of about 18 plenary lectures. In addition to this series, a number of single lectures on special subjects in the same fields will be delivered.

ITALY

Cement production increased

During 1953, Italian production of cement reached over 8 million tons, of which 2,200,000 were produced in the south. Although there were significant increases in production throughout Italy, the most remarkable was that of 36% (over 1952) in the south. This is largely due to the encouragement of industrialisation by the Cassa del Mezzogiorno; in 1939 the south produced only 850,000 tons, or 16% of total Italian production, compared with 27% in 1953. This figure will be even higher for 1954 when the new factories in Naples and Catania are working.

SWITZERLAND

Persian order for alkali plant

Two Zurich firms, L. von Roll A.G. and Krebs & Co. A.G., have won an international tender issued by the Teheran Water Supply Organisation for the construction of an electrolytic alkali plant, according to the *Neue Zuercher Zeitung*.

The plant is to produce caustic soda flakes, as well as 275 tons of liquid chlorine and 675 tons of ferric chloride p.a. The lye is to be delivered to the scrap industry and to oil refineries, while the chlorine will be used in Teheran's water purification plant.

SWEDEN

Sulphuric acid plant

A new, fully automatic plant for producing sulphuric acid from sulphur dioxide in the waste gases resulting from the copper smelting process has recently been put into operation at the Boliden Mining Co.'s copper smelting works at Rönnskär in north Sweden. About one-third of the sulphur dioxide in the waste gases and vapours, which are passed to atmosphere from the works' 475-ft. stack, is utilised in this way.

The plant, which has cost about Kr. 10 million (£690,000), is claimed to be the only one of its kind in Sweden. The present output, 90 tons per 24 hr., covers approximately one-tenth of Sweden's annual consumption of sulphuric acid, which is estimated at 350,000 tons. The growing use of sulphuric acid as a raw material in the chemical industry for fertilisers, explosives, rayon, etc., may call for an increase in the output, which is elastic within certain limits.

The washing and purification of the flue gases take place in a closed system, and the plant is operated by only two men per shift, in addition to staff for transport, overhaul, etc.

DENMARK

Cellulose-from-straw factory

A new Danish factory for the production of cellulose from straw at Fredericia (Jutland) is expected to go into production early in the autumn. The plant has an annual capacity of 16,000 tons of straw, or 7,000 tons of cellulose. This is slightly less than one-tenth of the amount which Denmark at present requires for paper making.

The project is the result of co-operation between Danish paper factories and farmers, and has been partially financed by a Mutual Security Agency loan of 6 million crowns.

TURKEY

Nitrogen factory

A nitrogen factory is to be set up at Kutahya and will use coal from the Saidomar mines; specifications have been drawn up by a United Kingdom firm. The estimated cost of the factory, excluding the power plant, is said to be T£60 million.

FORMOSA

Cracking unit ordered

The Chinese Petroleum Corporation has signed a contract with Fluor Corporation Ltd., Los Angeles, for the engineering, equipment procurement and construction supervision of a Socony type 45 Thermoform catalytic cracking unit at its Kaohsiung refinery in Taiwan, Formosa.

Charge stock to the unit, which will include a feed preparation and gas recovery system, will be 10,000 barrels daily, from which 6,500 b./day of distillate will be charged to the 'cat' cracker reactor.

The Chinese Petroleum Corporation has been processing crude oil imported from the Middle East in addition to a small amount of indigenous crude oil. The catalytic cracking unit is part of an extensive refinery expansion programme.

JAPAN

Titanium production

A total of 105 tons of titanium was produced during 1953, made up as follows:

	tons
Osaka Titanium Co. Ltd.	80
Japan Soda Co. Ltd.	13
Japan Electric Metallurgy Co. Ltd.	10
Mitsubishi Metal Co. Ltd.	2
	105

Exports during the year amounted to 90 tons, of which the major part went to the United States. The Titanium Makers' Association estimates that total production in 1954 will reach over 1,000 tons.

SOUTH AFRICA

Uranium developments at gold mines

It is estimated that the uranium plant of the Harmony Gold Mining Co. Ltd. will be commissioned some months after the gold reduction plant on that mine commences operations in the middle of the year and the uranium plants being erected at the Welkom and President Steyn mines are expected to be completed before the end of 1954. These two plants will initially treat the residue slimes of the President Brand Gold Mining Co. Ltd. and the President Steyn Gold Mining Co. Ltd. The uranium values obtained to date at the Welkom and Western Holdings mines do not justify their slimes residues being treated, and insufficient development has been done at the Free State Geduld mine to assess whether its slimes residue will be treated.

This is stated in the report of the directors of the Anglo American Corporation of South Africa Ltd. It is also recalled that production at the uranium and acid plants at Daggafontein Mines and Western Reefs Exploration & Development Co. commenced in March and September 1953, respectively. After initial difficulties the plants operated satisfactorily, the estimated profits (subject to adjustment) from the sales of uranium and sulphuric acid at

Daggafontein being £644,991, and at Western Reefs £246,645, in respect of the period ended December 31, 1953.

RHODESIA

Copper refinery

A scheme to construct in the near future a £5-million electrolytic copper refinery at Ndola has been announced by the Roan Antelope Copper Mines Ltd. The refinery, which will require about £3 million of capital, will have an initial capacity of between 55,000 and 60,000 long tons of electrolytic copper a year and will draw its power from the Rhodesian-Congo Border Power Corporation Ltd. Production is expected to begin during 1958. Roan Antelope Copper Mines will enter into a long-term contract to supply the refinery with up to 60,000 long tons p.a. of blister copper for refining into electrolytic shape. The design of the refinery will cater for the possibility of eventual expansion to 110,000 long tons of electrolytic copper. This would involve a further investment of about £1½ million at present-day price levels.

Cement factory

A £1½-million factory near Salisbury to produce about 100,000 tons p.a. of cement is planned by Associated Portland Cement Industries of Great Britain and the United South African Portland Cement & Associate Co.

FRENCH WEST AFRICA

Aluminium projects

It is reported that the French aluminium-producing group consisting of the Pechiney and Ugines companies is proposing to invest capital in French Guinea and in the Cameroons for setting up aluminium plants on the spot. This hinges largely on the question whether the cost of electricity produced by the newly inaugurated electricity generating plants will be sufficiently low to warrant the venture.

ARGENTINA

Steel industry planned

Argentina will soon begin building, with Peruvian and West German help, a steel industry with an annual production capacity of 1 million tons. The Compania Financiera del Peru will grant Argentina a credit for the purchase of steel plant and equipment from West Germany, and another credit after the first stage of the investment is completed. In addition, Peru will supply anthracite.

VENEZUELA

Chemical projects

The Venezuelan Development Corporation, a government body, has announced plans for building several new plants for the production of chlorine, caustic soda, yeast, ethyl alcohol, butyl alcohol, alcohol butyl-acid, citric acid, lactic acid, carbonic acid, glycerin, plastics and acetone.

PHILIPPINES

Aluminium project

An American concern, the Reynolds Metals Co., is to build a plant near Manila which it is claimed will be capable of filling the foil and sheet aluminium needs of the Philippine Islands. The factory will be built and operated by a specially created company to be known as the Reynolds-Philippines Corporation; 51% of the stock will be owned or controlled by Reynolds. Philippine interests will hold the remainder. The total capital required for the plant, expected to be operating by the end of 1954, is approximately \$3 million.

Rayon pulp plant

A New York engineering firm, Seaman & Seaman, is planning to set up a \$20-million pulp mill in the Philippines, which will produce the raw material for the manufacture of rayon. The company is understood to be discussing details of the plan with the Victorias Milling Co., of Negros, which would supply sugar-cane bagasse as the starting material for the plant.

UNITED STATES

\$15-million viscose plant for Yugoslavia

The Von Kohorn International Corporation and Oscar Kohorn & Co. Ltd. announce that they have been awarded a contract by the Yugoslav Government to build a \$15-million viscose works in Yugoslavia.

A substantial part of the machinery is being built in Japan and the Export-Import Bank of that country recently approved a credit for deliveries of machinery and equipment from Japan. Machinery is being manufactured by the Kohorn Co.'s Japanese licensees, the Mitsubishi Shipbuilding & Engineering Co. Ltd. and the Kotobuki Industry Co. Ltd. Electrical equipment is being supplied by the Tokyo Shibaura Electric Co. Ltd. American-built machinery and equipment as well as all engineering was being supplied by the Von Kohorn International Corporation.

Engineering work is nearing completion and deliveries of machinery and equipment are to start soon. Production is expected to commence by the end of next year.

Upon completion, the works will be placed in production by Von Kohorn, which will assume technical management of the works until full production is reached and Yugoslav personnel have been sufficiently trained to take over.

The integrated works will have a capacity of 50 million lb. p.a. of filament rayon yarn, rayon staple, rayon tyre yarn and transparent cellulose sheet.

According to a Reuter report from Belgrade, the viscose works is to be built at Loznica, about 50 miles west of Belgrade. Japanese technicians should arrive early in 1955 to install the machinery. When completed, the plant will have a daily production of 53 tons and is expected to save

Yugoslavia \$24 million p.a. in textile imports.

A report from Tokyo says that machinery and equipment worth \$12 million has been bought in Japan, while it is understood the Von Kohorn International Corporation of New York will supply approximately 10 to 15% of the equipment. This report says that the viscose works, when completed, will include a power plant and other installations requiring a total investment of \$25 million.

New petroleum-based paint ingredient

The Standard Oil Development Co. has developed a new petroleum-based chemical which it thinks will result in a host of pioneer products. These include paints with more resistance to scratching, to harsh chemicals and to other abuses.

The firm, an affiliate of the Standard Oil Co. (New Jersey) reports that Glidden Co. has been licensed to develop surface-coating uses for the new chemical, called *C-oil*. It is a heavy-bodied, sticky, almost colourless liquid based on butadiene. Semi-commercial quantities of *C-oil* are being produced in Esso Standard Oil Co. laboratories in Baton Rouge, Louisiana, but it will be several months before any new products made from the material reach the market.

Iso-octyl alcohol

The Gulf Oil Corporation has started production of iso-octyl alcohol at its new plant in Port Arthur, Texas. This marks the company's first move into the general organic chemical market. The new plant has an annual capacity of 9 million lb. of this alcohol and can be adapted to produce other alcohols. Completion of the Port Arthur facilities is the climax of a development programme by Gulf's research laboratories which is said to have successfully modified a process introduced by the Germans during the last war. The modified process is claimed to incorporate substantial improvements over the original method.

Paper project

The Hammermill Paper Co. has started construction of a \$5-million bleaching and pulping plant at Erie, Pennsylvania. The plant is expected to be operating by the middle of next year and will use the Hammermill/Neutracer process for making paper pulp from hardwood.

Mobile atomic exhibition

An American mobile exhibition has opened a tour of Italy designed to illustrate the peaceful applications of atomic energy. A similar exhibition is due to tour France, Belgium and other European countries illustrating the uses of atomic energy in agriculture, industry and medicine. The United States Information Service organised the exhibition.

CANADA

Giant chimney for new iron and nickel plant

Soaring 615 ft. above a base 22 ft. high, the chimney for the Copper Cliff, Ontario, iron-ore plant of the International Nickel Co. of Canada Ltd. will take the title of 'tallest in the British Commonwealth' which for many years has been held jointly by the two 500-ft. stacks at Inco's Copper Cliff smelter. The great height of the chimney at the new plant is to ensure proper diffusion of waste gases in the upper atmosphere. The chimney is being built of reinforced concrete lined throughout with special brick, and will weigh 17,000 tons.

It will contain over 500,000 lb. of reinforcing steel and nearly 100,000 lb. of insulating material. The stainless-steel coping for the top of the shell will weigh 9,000 lb. Inside diameter at the top will be 30 ft., and outside diameter at the base will be 63 ft. 3 in. Construction of the stack will be completed about the end of the year.

The new plant will make metallurgical history by recovering high-grade by-product iron ore from nickel ores mined

in the Sudbury district (see *CHEMICAL & PROCESS ENGINEERING*, 1954, 35 (1), 4). Initially treating 1,000 tons/day of nickel-bearing pyrrhotite removed from ore in the early stages of processing at Copper Cliff, the \$16-million plant will release smelter capacity enabling Inco to deliver 120 million lb. of nickel to the United States Government for defence purposes over the next five years. By taking temporary measures, International Nickel has already commenced shipments against this heavy commitment.

Nickel refinery nears completion

The first units—the gas re-forming and anhydrous ammonia plants—of Sherritt Gordon Mines' new \$24-million nickel refinery at Fort Saskatchewan, Alberta, have been brought on stream and are operating in excess of rated capacity. This huge refinery, the first of its kind in the world, has been engineered and is being constructed by Chemical Construction (Inter-American) Ltd., of Toronto. It embodies a chemical process for extracting and refining non-ferrous metals from their ores, thus by-passing conventional and more costly smelting and refining techniques.

Natural gas and nickel concentrates are the raw materials for the operation, with high-purity nickel, ammonia and ammonium sulphate as finished products. Completion of the final units was expected by the end of June. The plant will employ processes pioneered jointly by Sherritt Gordon and Chemical Construction Corporation.

IRAQ

Rayon and gypsum projects

There have been proposals for the establishment of a modern rayon factory in Iraq.

The Director-General of Industries submitted a report to the Development Board for a factory producing 1,500 tons p.a., half yarn and half fibre, together with associated plant for cellulose. The possibility of making rayon, as well as paper, from marsh reeds has also been raised.

A company in which the Industrial Bank holds shares is being established to produce gypsum for use in local building construction. There is already some production of juss, which resembles gypsum, but this has not been on a large scale.

A committee has been set up representing the Ministry of Economics, the Development Board and the Industrial Bank to consider the needs of the country for new industries.

Industries under consideration are glassware, tyres, electrical appliances, chemicals, carpets, car assembly plants, cement, textiles, paper and sugar. Industries approved would be financed partly by the Industrial Bank and partly by public subscription.

CHEMICAL & PROCESS ENGINEERING ENQUIRY BUREAU

Stratford House, 9 Eden Street, London, N.W.1

Readers requiring names of suppliers of raw materials, machinery or finished products should complete this form and attach it to their business note-heading. Please state approximate quantities required.

We wish to know names and addresses of suppliers of the following:

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